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ANNALS *of* SURGERY

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DEAD BONE GRAFTS TO REPAIR SKULL DEFECTS

By Boris E. Pankratiev, M.D.

of Kazan, Russia

FROM THE SURGICAL DEPARTMENT OF THE RIAJSKTOWN HOSPITAL

Recently, I have had the opportunity of applying dead human bone for cranioplastic purposes in four cases operated upon by me personally. In the first instance, I made use of a piece of skull bone taken from my museum collection, which bone had been that of a boy upon whom I had operated for a skull lesion before his death. In the three other cases I took the bone from cadavers.

The first successful attempt at cranioplasty with bones, according to Grekov's data, was made by Jacob von Mackren (Moiasson—Job van Meekren), who succeeded as early as 1670 in repairing, by using a piece of dog's bone, a defect in the skull of a Russian who had been hit on the head by a sword. It is interesting to note that the bone had to be removed because the Church held that implanting a bone from a beast into the human body was marring God's image in man.

In 1882 MacEwen and in 1891 Ricard transplanted the bones of dogs into human skulls; the former used the occipital bone, the latter the hip bone. Other attempts in transplanting dead bones into the human skull include the work of Laksh from a goose's skull, and Kuttner from an apes. Westermann was the first to apply a boiled bone in a complicated fracture of the hip. He removed a bone fragment eight centimetres long by three and one-half centimetres wide, boiled it, and transplanted it back into the damaged point. Martens, Bunge and others also approve this method of using a boiled bone. Abrajanov prepared a bone transplant by dissolving the fat by means of ether, and boiling it, making it soft and spongy and capable of being cut with a scissors. Barth and Grekov used bits of red-hot bone. Senn decalcified bones.

Later MacEwen suggested leaving damaged skull bones where they were and after trepanning, replacing the fragments as a mosaic. Dobrotvorsky used to cover a damaged area with pieces of rib. There have been other similar attempts. However, the sum total of such experiments is not great. Cranioplasty with dead human bones is not as yet a widespread practice in surgery. Different authors deal with the question in various ways. Axhausen, Petrov, Lexer and others consider it more expedient to use a live autotransplant with a periosteum. On the other hand, such authors as Barth, Turner, Zeller and others consider it possible to obtain good results with a dead bone by heterotransplanting.

Personally, I am not an opponent of the first group of surgeons and I find the use of the autotransplant quite expedient, but in some cases I am ready to second the opinion of the latter authors. The preliminary operation of taking the material from a live man may offer a certain interest for the surgeon, but it is highly disagreeable for the patient. In taking an autotransplant from the patient himself, or from another person, one may weaken a bone to such an extent that a fracture may occur at the site where the transplant was removed.

At times large transplants have to be taken for the skull which have to correspond exactly to the shape and size of the defect, and such transplants from the autoplastic point of view cannot be obtained. In one of my cases I had to cover a skull defect fifteen by ten centimetres. One can only obtain a transplant of such dimensions from the skull of a cadaver. With this plastic method one has the advantage of being able to choose the right size of the transplant, and also to prepare in advance the shape required; thus no valuable time is lost during the operation in its preparation. It is not simple, however, to accomplish this technic properly. These cases require meticulous care, as any pressure on the brain of an ill-adapted transplant may cause various undesirable complications.

As to the question of regeneration of the bones, according to Bielogorsdsky, transplanation of foreign dead bone raises the level of calcium in the blood, which fact must be taken into consideration. In the regenerative process the osteoblasts make use of the heightened level of calcium in the blood for a more rapid replacement of the defects of the skull. As in place of the resorbtion of the transplant, fresh bone is being formed, thus filling the existing defects, which would practically never close without plastic intervention—particularly if they are of any considerable size. Because of this fact, as pointed out by Bergmann, that bones of the skull *per se* practically have a limited regeneration ability.

We have to consider a point made by Grekov, that the edges of the transplant should come in close contact with the diploe of the defects in the human skull. For this purpose, before transplanting the bone, the diploe should be denuded and the old periosteal scar should be carefully cut out. When inserting the transplant between the dura mater and the periosteum or even bone between their fragments, by putting the transplant in touch with the diploe, we facilitate the regenerative process. In such cases the bone transplant prevents the periosteum from adhering to the dura mater.

The regenerative process in the skull bones proceeds very slowly. In very large transplants, when we have to cover large skull defects, even if one does not obtain a complete regeneration of the whole transplant, at any rate there is obtained an inner prothesis quite suitable in its chemical and morphological structure to the normal human bones.

Case I.—(No. 986.) Tuslukova, T. S., aged sixteen years, a Russian girl, was brought to the Surgical Department of the Riajsktown hospital November 3, 1928, with a complicated skull fracture, sustained by being struck on the head with a stone. Patient unconscious part of the time; profuse hæmorrhage. There was present a

lacerated skin wound five centimetres long in the middle line of the occipital bone. Probing disclosed a fracture of the skull at the site of the skin wound and a depression of the fragments, otherwise negative. Temperature, 36.6°C.; pulse, accelerated.

Operation.—The skull was immediately trephined, fragments of the bone were extracted until a skull defect formed three centimetres by two centimetres large. In order to cover this defect a dead skull bone was transplanted, which had been carefully sterilized first by boiling in a 2 per cent. solution of sodium bicarbonate and then in a physiological solution of 0.8 per cent. of sodium chloride.

The site of the lesion had been previously prepared by removing with a Luiner's bone extractor some of the inner plate of the skull of the patient, causing the outer plate to hang above the inner one. Having thus prepared the cavity the transplant was inserted behind the artificially formed prominences at the top and bottom of the outer plates of the skull; which remained fixed without even any retention sutures through the inner cerebral pressure upon the dura mater supporting the adjusted transplant. The hæmorrhage from the dura mater and from the diploe ceased at once. As a child's bone thinner than that of the patient had been transplanted, a hollow appeared on the site of the skull defect. An incision was made on the hip, and a piece of adipose tissue was transplanted in order to cover the skull hollow at the site of the wound. The lacerated edges of the skin wound on the head were cut out at the time of making this graft. The post-operative course of the patient was quite normal.. The wound healed by primary intention—except the two sutures which pulled through because of the tension, which was remedied by secondary tension suture. The fat transplant adhered firmly.

When the patient was discharged from the hospital five weeks after the accident and operation, there had been a complete repair of the original skull, and complete anatomical restoration, both of bone and of soft tissues. She has been examined twice during the year and a half since the operation. The skull defect has been completely covered with dense bone tissue. She feels well, has married, cares for her home, and helps with farm work.

Case II.—(No. 943.) Yerin, V. S., a Russian peasant, aged twenty-three years, unmarried, was brought to the Surgical Department November 14, 1929, on account of traumatic epilepsy and a skull defect. The condition was due to his having been hit eight years before with a horse shoe, causing a fracture of the fore part of the skull. His hearing had been greatly impaired by the injury; two and a half years after the trauma he began having epileptic attacks. These occurred two or three times a month. The patient was of medium build, and well nourished. On the forehead there was a scar adhering to the underlying tissues and slanting downwards from left to right, about seven centimetres in length and a disfiguring defect of the frontal bone six centimetres long. Pulsation of the brain was visible at the site of injury. The patient had an idiotic expression; answered questions with great difficulty; suffered from vertigo and was taciturn and melancholic. In addition to his deafness, there was a tingling in his ears. Behavior calm, except during epileptic seizures, otherwise negative.

Operation.—On November 21 the skull was trephined under a local anæsthesia of 0.5 per cent. novocaine solution. The scar was cut out; the depressed bone fragments were extracted, as well as a fragment of the frontal bone about 2 centimetres by one-half centimetre in size, which had not adhered to the surrounding bone scar, but which was pressing directly upon the brain tissue; several other similar separate small bone débris were also extracted. In order to facilitate the regeneration of the transplant, the edges of the skull defect were refreshed so as to denude the diploe. The skull defect, having the shape of a triangle seven centimetres in its base and about four centimetres high, was covered with a transplant taken from a cadaver, as in the previous case, at the morgue. The bone, after having been thoroughly sterilized was fastened to the edges of the skull defect by three wire sutures. The edges of the transplant had been properly adjusted to the previously denuded diploe and covered on the edges by fragments of the periosteum. The skin wound was closed by catgut sutures without drainage.

The post-operative course was normal. The operation produced a very rapid effect. Within two days the headaches ceased; the patient's expression became more natural; he answered questions readily and became less taciturn, and his hearing improved considerably. However, shortly before leaving the hospital on December 20, he had one attack of epilepsy. When discharged he felt well; the cosmetic effect was excellent.

May 24, 1930, the patient was examined; the transplant was found to be in good condition; the edges were smooth, and had apparently blended with the skull bones, which indicated that the regenerative process was going on normally. At home the patient had begun to perform different tasks about the house. After leaving the hospital, for a time he was free from epileptic attacks, but during an attack of influenza he had had slight convulsions, which ceased after his recovery. The patient, at the time of examination, had become more normal mentally, was less taciturn; his vertigo and headaches had ceased, and his hearing was much improved. He could perform different kinds of work in the house and even in the field. The skull defect was covered by a solid bone tissue, evidently newly formed, and partly by the transplant.

Case III.—(No. 957.) Lotarava, E. S., a Russian peasant girl, unmarried, fourteen years old, was brought to the Surgical Department November 16, 1929, on account of an osteosarcoma of the skull.

The patient's mother informed us that her daughter was born with a small bone tumor on her head. Recently a rapid growth of the tumor had been observed. At the same time the patient began to suffer from headaches. The patient was of normal stature, of regular constitution, and well nourished. In the area of the frontal bone, starting from the inner edge of the left eyebrow, a dense prominent bone tumor was present, in shape resembling a cock's comb, crossing the entire frontal bone—it extended over to both temporal bones, widening in this region. The general extent of the tumor in length from the before backwards, was fifteen centimetres, its width in the area of the temporal being ten centimetres. The swelling, as mentioned, was dense and prominent, the skin covering it above was not normally mobile; otherwise normal.

Operation.—Under a general ether anæsthesia the skull was trephined, and a bone tumor fifteen by ten centimetres was removed. The tumor was prominent not only externally, but impinged on the inner surface of the skull as well and caused severe headaches by its intracranial pressure. The enormous defect formed by the extraction of the osteosarcoma was covered with a transplant of a suitable size and shape taken from a cadaver's skull. The edges of the transplant were shaped and smoothed with a file, then sterilized. It was fastened in by means of four wire sutures and covered with the periosteum. In two regions where the transplant had not come in touch with the dura mater, where it had fallen in as a result of tumor protuberances, in order to avoid a dead space, pieces of fat taken from the patient's hip were inserted. Wound closed without drainage.

Immediately after post-operative there was a cessation of respiration, followed quickly by cardiac failure, notwithstanding adequate stimulation, resuscitation was not effected. However, the anatomical restoration of the defect, after the tumor was extracted, was excellent.

Case IV.—(No. 347.) Simanin, M. I., five months old, a Russian peasant's daughter, was brought to the Surgical Department on account of cerebral hernia April 28, 1930. The mother said that the child was born with a tumor near the right eye, about the size of a pigeon's egg. As the infant grew, the tumor increased in size. The mother had three other children, all normal. Before entering the hospital, the child's entire body became covered with a scrofulous eruption. No pathological symptoms of heredity.

For its age the child was of normal stature, of regular development, slightly undernourished. On the face, between the right eye and the bridge of the nose, there was a growth the size of a hen's egg; it was tense. It covered a part of the right eye as well as the nostril, and obstructed the child's breathing. When the child cried, the swelling

became more tense and compact and prominent. The hairy part of the head presented a scrofulous eruption. The submaxillary and inguinal or lymphatic glands could be palpated. *Diagnosis.*—Cerebral hernia.

Operation.—May 8, 1930, under ether anæsthesia, an oblique incision was made on the protuberant surface downward. The hernial pouch was opened, discharging a large quantity of transparent cerebral liquid. In examining the inner surface of the protrusion, a bone defect one-half centimetre was found on the right base of the skull. The edges of this bone defect were limited by the frontal and the ethmoid bones, and by the anterior portion of the upper jaw-bone as well. The edges of the defect were refreshed and a piece of bone removed from the tibia of a cadaver, thoroughly sterilized by boiling first in a 2 per cent. sodium bichloride solution and next in 0.8 per cent. physiological salt solution, and inserted into the defect. This oblong piece of bone corresponding in size to the skull defect was fastened to the frontal edge of the defect, which served to stop the escape of the cerebral fluid.

The hernial sac, its inner surface consisting of an extension of the hard cerebral membrane, was removed, as well as the redundant skin, and the wound closed without drainage by a double catgut suture.

The post-operative course was without any complications. There was no post-operative vomiting. The wound healed by primary intention. Twenty days after the operation the child was allowed to leave the hospital, and was referred to the pædiatrician for treatment of the scrofula.

COMMENTS.—Here are presented four histories of skull repair by means of dead human bones. In the first case, cranioplasty was performed on account of a recent complicated skull fracture, with both an immediate and a final good result.

In the second case, cranioplasty was used to cover an old defect causing traumatic epilepsy, and a disfiguring scar on the forehead. The result was favorable; observation of the patient continued for six months after the operation, showed permanent improvement.

In the third case, it was used where there was an enormous skull defect fifteen by ten centimetres in size, after the extraction of an osteosarcoma of the skull case. The patient unfortunately died from the effects of anæsthesia. The operation proceeded smoothly, offering no difficulties, but the patient's unexpected inability to withstand the anæsthetic prevents my reporting a case which I believe would have shown an excellent surgical result.

In the fourth case, a congenital defect of a child's skull and cerebral hernia were successfully treated. Considering the weakened organism here dealt with, the case shows the technical correctness and expediency of the surgical method of bone transplantation.

The method is applicable both to fresh, non-infected wounds and also to old bone defects with scar tissue. In case infection may be anticipated, applying cranioplasty seems inexpedient. The later suppuration of the wound would probably necessitate the extraction of the transplant, preventing a favorable result. Such defects as those formed after extracting bone skull tumors, congenital cerebral hernia, may be considered as amenable to cranioplasty.

I wish to emphasize the importance of the suggestion made by Grekov

concerning the careful application of the transplant to the denuded diploe, to promote the regenerative process. The covering of the transplant by the periosteum contributes to the improvement of the covering of the defect as well, aided to a certain degree by the hard cerebral membrane. In operating we have to spare the periosteum as well as the dura mater, bearing in mind that in general the regenerative processes of the skull bones are very limited.

In addition to the strictest aseptic measures, the following details were carefully observed in these operations. Applying a bone transplant of exact size and shape, and the fastening of it by wire sutures. All of these measures are to be strictly observed, to prevent the possibility of post-operative meningitis as well as acute purulent encephalitis. In spite of the manifest advantages of replacing skull defects with dead human skull bone, this method of repair is not yet widespread. The method has many advantages, for the transplant is of material approaching very closely, by its chemical and morphological structure, the skull bones receiving the transplant.

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STUDIES ON ACUTE CRANIAL AND INTRACRANIAL INJURIES

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from the department of neurosurgery, receiving hospital

Cranial and intracranial injuries are at present an important surgical problem, and it is probable that they will increase in importance for many years. In the present paper I propose to discuss conclusions from a study of cases entering the Receiving Hospital for an eighteen-month period (January, 1930, to July, 1931). During this period the position of this institution has been rather unique in that practically all cases picked up by the police ambulance in the Detroit area were brought here. It is evident, therefore, that this study represents all types of cases, of different social states and of all ages. A certain number left the hospital and were transferred to other places, but in the majority only after they were out of danger. A certain number of the transferred group were also followed up in this study. Several of the fatal cases were autopsied at the Coroner's office, to which the author is indebted. I also thank Dr. E. T. Olsen and the members of the surgical staff for coöperation and advice.

In the entire series of 718 cases 475 were proven to have skull fracture (ray, inspection and autopsy). Two hundred and forty-six showed clinical evidences and spinal-fluid findings indicative of brain dysfunction and damage. It is not sufficient to discuss only cases with skull fracture without due consideration being given those patients who, even though they were not demonstrated to have a fracture, actually suffered brain dysfunction. Among some of the latter group the clinical evidences may be just as severe as those with serious skull injuries. If, on one hand, one discussed cases of proven skull fracture only, he would of necessity omit many patients with severe brain injury due to trauma. On the other hand, a consideration of cases of brain injury alone would necessitate the omission from one's series of many cases of proven skull fracture with no evidences of brain dysfunction or injury. It is, therefore, better to consider these two groups of cases together for a better understanding and treatment of patients. From a statistical standpoint, the respective groups should be properly evaluated. It is true that even though a case of skull fracture may not have associated brain injury his group presents a poorer prognosis than the group with no fracture. Skull fracture is a serious condition and should be considered so. The low mortality rates appearing in the literature lately do not do justice to this fact, for under the guise of skull fracture many cases of minor head injuries are also considered, thus bringing the mortality down. However, it is true that skull-fracture mortality today should be lower than ten or fifteen years ago, for with the refinement of

X-ray technic and insistence on the part of hospital authorities to ray practically all cases of head injury, many asymptomatic cases of fracture are added to one's series. Years ago such cases were undoubtedly considered under the classification of "concussion" and were probably never suspected of having a fractured skull.

Before going into a discussion of my thesis I think it advisable to say a few words about X-rays in skull-fracture work. An increasing number of skull injuries in late years has made X-ray examination of such cases an important procedure in most hospitals. Medico-legal aspects also have made it important to use rays routinely in all cases of suspected injury to the head. At present X-ray technic is far enough advanced to enable an experienced röntgenologist to demonstrate pathology in the greatest majority of cases. It is a well-known fact that a certain number of cases diagnosed as alcoholics, demented individuals, *etc.*, have been properly classified by the demonstration of fracture by ray.

The use of Röntgen-rays in cases of suspected skull fracture, to my mind, has been slightly overemphasized from a prognostic standpoint. When one realizes that the demonstration of fracture and its extent is another laboratory aid, its utilization as such is only in conjunction with other clinical and laboratory findings. As emphasized by several investigators it is the associated brain damage which is all-important in cases of fracture of the skull.

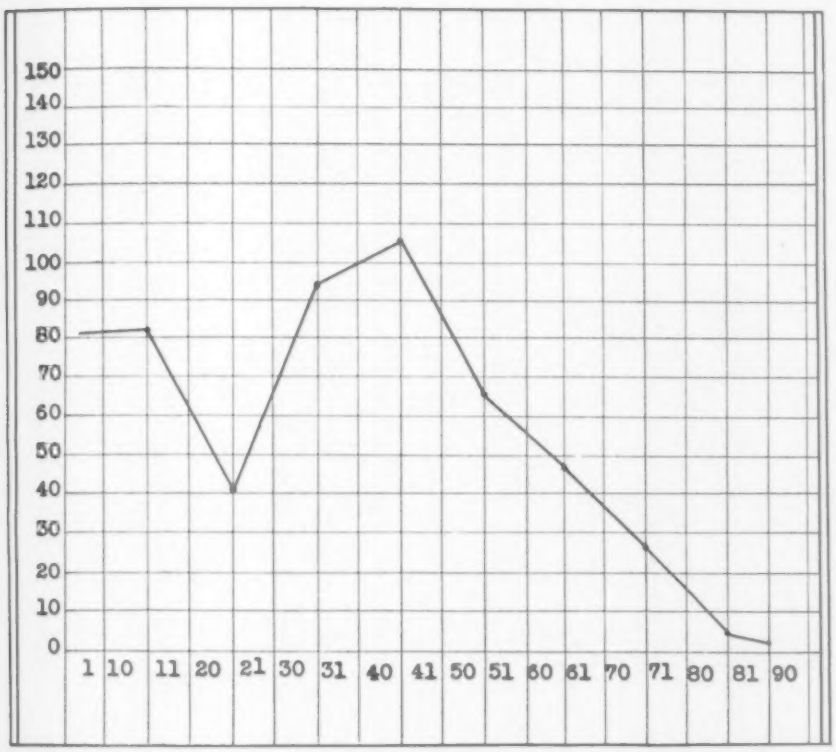
In this institution suspected cases are rayed within twelve hours after entrance into the hospital if their condition permits. It is true that in a certain number one gathers invaluable data from the ray examination which may alter the course of treatment. The location of the fracture may be important in some cases of middle meningeal hæmorrhage. Its position along with other clinical data may enable one to make a diagnosis of orbital frontal lacerations (see page 350). The type of fracture, *i.e.*, fissured, diastatic, depressed or stellate, is important in some cases at least from a surgical standpoint.

At the Receiving Hospital (R. J. Kenning, Röntgenologist) a rapid technic is used in order to secure diagnostic röntgenograms. Approximately seventy kilowatts and forty milliampere at twenty-four inches with double screen has been found to be efficient in the demonstration of fracture in the greatest majority of the cases. A number of patients are usually confused and irritable so that question of immobilization is of paramount importance and this rapid technic has enabled the department to get good films whereas with the longer technic of bucky diaphragm it would be rather difficult. Routinely A.P., P.A. and right and left lateral plates are procured. In some cases, when the patient's condition permits, stereo-bucky plates are also procured. Where a fracture is suspected in the mastoid area, such as in cases of bleeding from the ear, the patients are rayed using the usual right and left mastoid positions.

Middle meningeal groove markings should not be difficult to recognize

and should not be mistaken for fractures. Suture lines are not usually confusing. One has to be careful in diagnosing diastatic fractures and make sure that his technic is quite perfect. It is important to keep in mind that fine lines of fracture may not appear on the plate in the presence of poor focusing on the pathology. The clinician can help the röntgenologist a great deal by giving him as much of the clinical data as possible because by so doing the latter may be able to demonstrate better any fracture lines by focusing directly on the suspected area. In some cases it will be necessary to re-ray the patient for the demonstration of the fracture. I recall

TABLE I



This is to show the age distribution in cases of skull fracture in the present study. Note that between the ages of ten and twenty the number decreases.

one case where the patient was rayed three times and finally the mastoid exposure showed a fracture line which was suspected and yet had not been previously demonstrated by rays.

Distribution and Type of Fracture.—Table II shows the distribution of fractures in the series. I have divided the skull into thirds, namely, the anterior third, extending as far back as the fronto-parietal sutures, including the anterior fossa; the middle third, extending from the fronto-parietal sutures to the occipito-parietal, including the middle fossa; and the posterior third, made up of the occipital vault and the posterior fossa. It seems to me

that this classification is much simpler, although I realize that it is only based on topography and, therefore, may not do justice to certain principles of the genesis of skull fractures. It is also true that in a certain number the fracture may involve the length or circumference of the vault. It is seen that middle-third fractures clinically are the most frequent (Table II), although in autopsy material (LeCount and Apfelbach) posterior third fractures are the most numerous. Such a discrepancy speaks of the greater mortality with fractures of the posterior third of the skull. Fractures involving the anterior third of the skull may be subdivided into those of the

TABLE II

Analysis of 475 Cases of Positive Skull Fractures

ANTERIOR THIRD OF SKULL					MIDDLE THIRD OF SKULL				POSTERIOR THIRD OF SKULL			
137 CASES OR 26.5%					237 CASES OR 46.02%				141 CASES OR 27.4%			
RIGHT	LEFT	F.S.	BASE	DEPRESSED	RIGHT	LEFT	BASE	DEPRESSED	RIGHT	LEFT	O.M.	DEPRESSED
60	77	29 or 21.1 %	37 or 27.1 %	30 or 21.8 %	120	117	50 or 21.1 %	32 or 13.5 %	67	74	26 or 18.4 %	7 or 4.9 %

This is to show the position of fracture in the series. Fractures involving the middle third of the skull are most numerous. There were fourteen cases with multiple fractures in this group study. F.S., frontal sinus; O.M., fractures involving foramen magnum.

right and the left side, those involving the frontal sinus, those involving the anterior fossa and those showing depressions. A comparison with the middle-third fractures shows that base involvement and depressions are more common in the anterior third of the skull. It is probably true, however, that most of the isolated, short middle-fossa fractures are missed by ray. Fractures in the posterior third of the skull have been sub-divided into those involving the right and the left side, those extending into the foramen magnum, and those showing depressions. It is to be noted that depressions in the posterior third of the skull are infrequent.

Depressed and Compound Depressed Fractures.—As shown in Table III, there were sixty-nine cases of depressed and compound depressed fractures in the series. Among those with simple depressions a certain number did not show any clinical evidences of brain damage. It appears from the table that depressions occur most frequently in the middle third of the skull, although on a percentage basis they are more common in the anterior third. Undoubtedly, one reason for this is the fact that frontal sinus depressions are also included in the anterior third of the skull in the above classification. Depressions in the posterior third are infrequent and apparently serious

TABLE III

Analysis of 69 Cases of Depressed Fracture

BRAIN INJURY				DISTRIBUTION OF FRACTURES						DEPRESSED COMPOUND FRACTURES				TREATMENT				RESULTS	
NONE	SLIGHT	DEFINITE	SEVERE	ANTERIOR THIRD SKULL		MIDDLE THIRD SKULL		POSTERIOR THIRD SKULL		14 CASES				OPERATED		NOT OPERATED		69 CASES TOTAL	
13	17	18	21	30		32		7		OPERATED		NOT OPERATED		34		35		RECOVERED	DIED
				RECOVERED	DIED	RECOVERED	DIED	RECOVERED	DIED	10		4		RECOVERED	DIED	RECOVERED	DIED	51	18
				27	6	25	8	3	4	RECOVERED	DIED	RECOVERED	DIED	24	10	27	8	MORTALITY 26.1%	
										8	2	0	4						

An analysis of depressed fractures in the series. Note that posterior third depressions are infrequent and very serious. Thirty in this group had little or no evidences of brain injury.

as concerns prognosis. There were fourteen cases of compound depression of which ten were operated upon and four were in too serious a condition for surgical intervention. It has been the policy in this institution to take care of compound depressions as soon as the patient's condition permits. In simple depressions with no evidences of brain damage it is left to the patient to decide whether or not he would care to have the depression corrected. A great many in this group refuse operation and a majority of those who were followed up apparently were getting along without any sequelæ. (Several have been followed up for eighteen months or more.) The follow-up studies of Glaser, Ireland, and others in cases of depressed fractures are instructive. In this connection the presence of chronic in-

fections, such as lues, may be a factor in the production of the undesirable sequelæ seen in some of the cases. Simple depressions which are operated on are treated according to standard technic. (See Treatment.)

Frontal Sinus Fractures.—The subject of frontal sinus fractures has been considered by several writers. The contributions of Teachenor, Peet, Andruss, and others are helpful and worthy of careful study. In a previous contribution in collaboration with Dr. H. K. Shawan, I reported a series of 125 sinus fractures. The incidence in this series is about the same as previously reported. The results are again very gratifying with two deaths among twenty-nine such cases. There was no meningitis in this series. Table IV is an analysis of the sinus fractures. It may be seen that the incidence of clinical evidences of brain injury is low. There were two cases of compound fracture which were operated on with good results. In both

TABLE IV

Analysis of 29 Cases of Frontal Sinus Fractures

DISCHARGE FROM NOSE			BRAIN INJURY				DISTRIBUTION OF FRACTURES									EXTENSION OF SINUS FRACTURES			OPERATIONS		RESULT	
NONE	EPISTAXIS	C.S. DISCHARGE	NONE	SLIGHT	DEFINITE	SERIOUS	RIGHT			LEFT			BI-LATERAL			INTO VERTEX	INTO BASE	OUTER WALL OF SINUS	2		RECOVERED	DIED
							9 CASES			14 CASES			7 CASES									
							SIMPLE	DEPRESSED	COMPOUND	SIMPLE	DEPRESSED	COMPOUND	SIMPLE	DEPRESSED	COMPOUND				RECOVERED	DIED		
18	11	0	8	12	8	1	8	1	0	9	5	1	4	3	1	25	16	7	2	0	27	2

An analysis of fractures involving the frontal sinus. A majority had little or no clinical evidences of brain damage.

a modified Killian operation was performed. They both recovered. It is of interest to note the extension of the sinus fracture into the vertex or base. In the presence of such conditions some authors have considered the cases of a compound nature insofar as the contents of the cranial cavity are concerned. They have thought it advisable to explore the sinus in order to prevent infection. It is surprising to note that most of these patients recover with conservative treatment. There were two cases of aërocele of the sinus which recovered. Two other patients had cloudy sinuses indicative of intrasinus bleeding; they also recovered. It should again be emphasized that "wholesale" operating in this region is a poor policy; first, because such operative intervention is not necessary to save the life of the patient; second, because operations in this region are followed by deformities which are a psychic problem to the patient; and, third, because any operative procedure does shock the patient and may accentuate the signs and symptoms of brain injury.

Fractures Involving the Foramen Magnum.—Fractures of the base of the skull, particularly those of the posterior third, have been considered serious. Undoubtedly, there is ample evidence to show that this assumption is correct. However, from this present study, I am led to believe that a certain number of posterior fossa fractures may be practically asymptomatic because of lack of associated brain damage. A fracture of the skull as such is of little significance; it is the associated brain injury that is important, as well as the complications caused by the fracture, such as meningitis, infection of the brain, *etc.* Posterior fossa fractures are notorious in the production of contrecoup damage to the brain. In the LeCount and Apfelbach series the incidence was 78 per cent.

Linear fractures extending into the base of the posterior third of the skull may be roughly divided into three groups: first, those passing through the more central portion of the foramen magnum; second, those passing through the more lateral portion of the foramen magnum; and, third, those passing lateral to the foramen and usually involving the jugular foramen. In my experience it has been generally true that with a more lateral fracture at the base, the brain damage has been more severe. With a fracture in close proximity to the centre of the foramen magnum a certain amount of the force causing the fracture is buffered by the elasticity of the tissues in this situation, and, therefore, this force is limited to the place where the blow was given. With a fracture more laterally placed the force behind the blow is transmitted to the general cavity of the cranium with the ensuing brain damage so common in fractures of this type. This is a mere generalization and seems to hold true at least in the present series. When the blow is severe enough to cause the foramen magnum fracture to extend through the basilar process of the occipital, the associated signs of the brain injury are undoubtedly marked.

In the present series there are twenty-six cases with occipital fractures extending into the foramen magnum. The age distribution is interesting in that six of the entire group were under ten years. In a previously recorded series such a high incidence among the younger group is also noticeable. Clinical evidences of brain injury were not present among ten, with slight evidences among another thirteen. It is true that this analysis is based on ray findings and therefore does not represent a true cross-section of cases with such fractures. It is also true, however, that in the autopsied group the occipital fractures were mostly lateral to the foramen magnum. In presenting the above paragraph or two I endeavor to show that certainly a large number of foramen magnum fractures may be practically asymptomatic and that this is more true in cases with fractures involving the more central portion of the foramen and not extending into the basilar process. Bleeding from the ears occurred more frequently with such fractures as compared with the entire series. (See Table V.)

General Clinical and Laboratory Considerations.—*Age Distribution.*—Among those with skull fracture the age distribution is interesting.

Between the ages of one and ten years there are a great many cases, but the number decreases between the ages of eleven to twenty, probably because in the first decade the ability to size up situations is not so well developed whereas in the second decade the young person has learned certain fundamental principles of how to protect himself against injury. From twenty on the number of cases increases. The boy now has his car, he is just beginning to experience the novelty of getting intoxicated, *etc.* The greatest number of cases appear in the fourth decade. From this period on the number decreases due to a lower percentage of people alive in the higher denominations, and also because they are less active. Table I shows a diagrammatic representation of the age distribution in cases of skull fracture in the series.

Etiology.—By far a majority sustained fractures in automobile accidents. A history of fall was obtainable in a certain number. A few patients gave

TABLE V

Analysis of 26 Cases of Fractures Extending into the Foramen Magnum

ETIOLOGY					AGE DISTRIBUTION									BRAIN INJURY				BLEEDING EARS			RESULT	
AUTO	STREET CAR	BLOW	FALL	UNDETERMINED	UNDER 10	UNDER 20	UNDER 30	UNDER 40	UNDER 50	UNDER 60	UNDER 70	UNDER 80	UNDER 90	NONE	SLIGHT	DEFINITE	SERIOUS	RIGHT	LEFT	BILATERAL	DIED	RECOVERED
15	3	1	4	3	6	1	5	3	4	5	1	0	1	10	13	2	1	2	4	1	1	25

Analysis of fractures extending into the foramen magnum. A majority had little or no evidences of brain damage. A great many occurred among patients under the age of ten.

a history of direct blow on the head. A number had gunshot wounds. The majority, however, were in accidents, which may have injured any part of the body. This is important from the standpoint of treatment, for even though there may be evidence of skull injury, other parts of the body such as spinal column and cord, chest, abdomen and extremities may also be implicated. In the present series at least twenty-five deaths were caused by co-existent pathology elsewhere. A history of the accident is therefore important, in that direct blows to the head are more apt to cause local injury alone.

History of alcohol and alcoholic breath were noted among 112 of the cases under the classification of skull fracture. The mortality in this group does not present any peculiarities as compared with that of the general series. A combination of alcoholism and head injury in the beginning gives one the impression of serious prognosis. However, in a great many the picture changes within twelve to twenty-four hours. Acute alcoholism is a factor in the causation of skull fracture. After all, a normal person—barring tender age—with normal reaction time is not apt to become en-

tangled in accidents, and the majority of skull injuries are seen among those less alert and more or less partially incapacitated individuals. It may be an error of refraction in some, poor mentality and lowered brain function in others, chronic alcoholic degeneration, *etc.* I think it is true that under the influence of alcohol many a person is hurt who, under normal conditions, would probably be free of accidents.

Temperature, Pulse, Respirations and Blood-pressure.—In cases of brain injury, temperature, pulse, respirations and blood-pressure should be recorded frequently and particularly changes should be observed. Alterations in these various clinical data have been the subject of careful study in the hands of several authors (Kocher, 1901; Holbrook, 1924; McClure and Crawford, 1928; McCreery and Berry, 1928; Peet, 1928; Fay, 1930; and others). In some papers I think their significance is overestimated; in others possibly it is underestimated. It is my belief that one can learn something about the patient and his general condition by studying every and all clinical findings. In some cases, as is natural, some clinical data will be found to be more important and decisive than others, but an effort to correlation is very important, and would undoubtedly be productive of better diagnoses and treatment.

Temperature.—Temperature changes are of important prognostic value. In the initial state of shock the presence of subnormal temperature and with increasing intracranial pressure and traumatic encephalitis the increase in temperature are important to observe. If a temperature (rectal) is above 105°, and attributable to brain damage and increased intracranial pressure, it is, as a rule, of grave prognostic value. I have seen very few among them recover, and autopsy in the majority of the fatal cases did not show any pathology corrigible by any present-day procedure. I think in some cases increase in temperature, not attributable to brain damage, may be an expression of serum disease, in that all these cases of head injury with lacerations are given tetanus antitoxin. High temperature readings in children are not so serious as in adults, a fact stressed by Ireland.

Pulse and respirations.—It is unfortunate that true pictures of pulse and respirations as in cases of ideal increased intracranial pressure do not obtain frequently in patients with brain injury. Low pulse and increasing respirations were seen rarely, at least insofar as the series presented is concerned. However, in a certain number of cases this manifestation does occur, and, if so, it should be given its relative value in the treatment of the patient. Increase in respirations seems to be a more sensitive sign of increase in intracranial pressure and traumatic encephalitis. In order to properly evaluate such clinical data one should emphasize the importance of frequent readings for in the absence of such procedure changes are not perceived, and if so they may not be considered so significant.

Blood-pressure.—Much has been said concerning the significance of blood-pressure determinations in cases of craniocerebral injury. Rising blood-pressure, if present, is undoubtedly due to a medullary stimulation

However, in the majority of cases, blood-pressure determinations frequently made are of no significance as a measure of degree of intracranial pressure. This is essentially the conclusion arrived at by Holbrook, 924; McCreery and Berry, 1928; Fay, 1930; and others. Particularly is this brought out when one compares spinal-fluid pressure determinations with blood-pressure. In the majority of the cases studied the discrepancy is very marked. It is true that one should insist upon blood-pressure determinations in every case of cerebral injury, but one should also be prepared to discard readings in most cases as of any clinical value whatever. Blood-pressure findings tell us of general condition of the patient as to whether or not he is in shock, *etc.* More important than changes in blood-pressure, the state of pulse pressure seems to me of great prognostic significance. Particularly when the pulse pressure is equal to the systolic is a grave outcome to be expected. I have seen eleven cases with blood-pressure determinations comparable to 120/0; 100/0; *etc.*, where the mortality was over 90 per cent. In the present series there were two such cases. The physiological explanation of this phenomenon is probably as follows: With too much irritation of the vasoconstrictor centre a paralysis of the same ensues, with consequent peripheral vasodilation, hence lack of diastolic pressure. In such cases, then, the only pressure found in the arteries is that imparted by the action of the heart. In conclusion, I may say that blood-pressure determinations in craniocerebral injuries are found to be valueless, as an index of increased intracranial pressure, in the greatest majority of cases.

Discharge from Body Orifices.—Bleeding from body orifices is a common manifestation in cases of craniocerebral injury. It must be emphasized that the same etiological factor may be operative in the damage to other parts of the body even though the cranial bones and contents may be implicated. For instance, in one case of head injury there was rupture of the bladder, in another there was a rupture of the kidney. One had severe hæmorrhage from the vagina on a traumatic basis. The most common orifices from which bleeding may occur, however, are the ears, the nose and the mouth. In the next few paragraphs I shall consider these various complications rather briefly for they are well known and studied entities.

Discharge from the Ears.—Many contributions discuss this phase of the work. (Besley, 1918; Stewart, 1921; Vance, 1927; Davis, 1928; Mccreery and Berry, 1928; and others.) Vance finds that middle-ear-infection was the most common etiological factor in meningitis due to trauma. In Table VI I have analyzed the cases with discharge from the ear. One hundred twenty-nine patients had bleeding, cerebrospinal-fluid discharge or a combination of both. The mortality from unilateral discharge in this group is lower than in my previous presentation. (Gurdjian, 1932.) The mortality from bilateral bleeding is about the same as before. There were three cases of otitis media and two cases of mastoiditis; the latter were treated conservatively and they recovered. Facial paralysis as a complication of aural bleeding occurred in about 11 per cent. of the cases. A majority of

these recovered sufficiently to close the eye within two weeks after the onset. Most of them had functional recovery within two months. In two cases of unilateral facial paralysis I know the condition persisted over six months. In two cases there was bilateral facial paralysis, one in a child five years of age. The typical expressionless face with inability to close the eyes and pucker the mouth were seen. He was much better within three months, more so in the upper half of the face. The other case of bilateral facial palsy died in the hospital. They had bleeding from both ears. Particularly in the beginning there is a definite difference in the ability to taste in the two halves of the anterior two-thirds of the tongue in these cases. This seems to disappear as the facial musculature returns to normalcy.

The X-ray findings are again commendable. A high percentage of posi-

TABLE VI

Analysis of 129 Cases of Bleeding from the Ear

RIGHT EAR				LEFT EAR				BILATERAL				COMPLICATIONS								X-RAY FINDINGS									
51 CASES				49 CASES				29 CASES				MENINGITIS		OTITIS MEDIA		MASTOIDITIS		FACIAL PARALYSIS		RAYED CASES UNILATERAL BLEEDING		RAYED CASES BILATERAL BLEEDING		SITE OF FRACTURE IN RELATION TO AURAL BLEED					
REC.		DIED		REC.		DIED		REC.		DIED																			
35		16		34		15		9		20		2		3		2				84		16							
Blood	C. S. Disch.	Blood	C. S. Disch.	Blood	C. S. Disch.	Blood	C. S. Disch.	Blood	C. S. Disch.	Blood	C. S. Disch.	Rec.	Died	Rec.	Died	Rec.	Died	Unilateral	Bilateral	Positive	Negative	Positive	Negative	ANTERIOR THIRD OF SKULL	MIDDLE THIRD OF SKULL	POSTERIOR THIRD OF SKULL			
35	0	15	1	28	4	12	2	9	0	18	1	1	1	3	0	2	0	12	2	73	11	15	1	15	48	29			
MORTALITY 31.3%				MORTALITY 30.6%				MORTALITY 68.9%												POSITIVE WITH UNILATERAL BLEEDING 87%									

Analysis of bleeding or cerebrospinal-fluid leakage from the ear. Note the X-ray findings and the distribution of fracture in these cases. Fully 55 per cent. had fractures in the mastoid region either extending into the posterior third or the middle third of the skull.

tive by ray fractures are noted among those with unilateral aural bleeding. Furthermore, it is also to be emphasized that the fracture may not be in the middle third of the skull. A certain number had fractures in the anterior and posterior thirds of the skull. This is corroborated by some of the autopsy findings where in a case with bleeding from the ear there was no fracture in close proximity to the petrous bone of the same side. It illustrates the fact that aural bleeding is just as much an index of severity of blow as it is an argument for an adjacent fracture.

In this group of aural discharge there were two cases of meningitis. One died and the other recovered following treatment by repeated lumbar punctures. In the latter a strep organism was isolated which had the cultural characteristics of Koch-Weeks bacillus. There were eight cases of cerebrospinal-fluid discharge from the ear and none developed meningitis. One

had clear fluid draining for about five days; he was in the hospital for about two months and was unconscious or disoriented for about forty days. He left the institution fully recovered and when seen about three months after discharge he was still in good condition.

In the majority, a few days following the accident, hearing is quite within normal limits, with the exception of a slight discrepancy between bone conduction and air conduction, the latter being impaired. In a certain number, annoying tinnitus is experienced, which usually disappears within two months. In this series there were no cases of complete deafness in the surviving group. Thirteen complained of tinnitus and poor hearing on the affected side which subsided rather quickly. Excellent papers have been written on the subject of ear changes following head injuries by Brünner, 1925; Linthicum and Rand, 1931; Swift, 1931; and others. Particularly Linthicum and Rand give a full account of neurological changes in post-traumatic cases. Accordingly, equilibratory complaints are common and they are attributed to a mixed central- and end-organ damage. They state that in some of these cases vestibular tests may give results similar to those obtained in cases of typical cerebellopontine-angle tumor.

The treatment in cases with aural bleeding is conservative, as was brought out in my previous communication. Undue and unnecessary examinations of the ear are avoided. If the bleeding has stopped, the ear is left alone. If there is still some discharge, a mastoid dressing is applied after cleansing the external ear and a portion of the external canal with some antiseptic solution. In the absence of complaints and unexplainable clinical course I pay no attention to the ear. In the presence of a complicating facial paralysis, the affected side of the face may be splinted by using adhesive straps with a view to elevate the angle of the mouth and suggest light massage of the face by the coöperative patient. In the majority this is not necessary, however, for beginning return of function is evidenced by the patient's ability to close the eye better. In one severe case of facial palsy I thought it advisable to keep the upper lid down with adhesive in order to do away with corneal complications.

Bleeding from the Nose.—This complication was present among 24 per cent. of the group with fracture of the skull. Four cases had cerebrospinal rhinorrhœa. The latter complication is at times difficult to recognize because of the associated bleeding. In one case the rhinorrhœa persisted for about a week with the patient doing well; then rather suddenly the patient developed evidences of meningitis. Autopsy showed a fine fracture about one centimetre in length along the roof of the sphenoid sinus, about one centimetre from the optic foramen on the right. There was very little organization at the site of fracture. It seems to me it would have been practically impossible to reach this region extradurally as Peet suggests in cases of cerebrospinal rhinorrhœa. When the fracture is over the paranasal sinuses, particularly the ethmoids and sphenoids, one should also keep in mind the fact that the roof of these spaces may be of very thin bone

and therefore easily crushed by the dissecting instruments and thus make matters worse. It seems that operative procedures to curb the incidence of meningitis in such cases have many drawbacks and that it would be ideal to have some prophylactic serum measure to prevent meningeal involvement. In some cases the bleeding is so profuse from the nose that measures have to be thought of to prevent exsanguination. In such cases we have resorted to packing the nostrils. However, in the majority the bleeding stops within a short time after the accident.

Bloody or cerebrospinal discharge from the nose is a serious manifestation in cases of skull fracture. Meningitis in this series occurred more frequently among those with bloody discharge from the nose. There were three such cases. As stated above, it would be brilliant work if some prophylactic measure in the form of serum treatment were discovered to curb the incidence of meningitis in such cases for operative prophylaxis is too severe and would expose to danger altogether too many lives in order to save a very few, if any. Patients with this complication are asked to refrain from blowing the nose. No intranasal douches are used. In the presence of cerebrospinal fluid discharge the question of a frontal flap operation with a view to repair the area of damage is kept in mind.

Vomiting.—Vomiting is a common occurrence, particularly within the first few hours after the accident. One hundred thirteen among those with proven fracture had this complication (21 per cent.). Occasionally it is bloody; if so frequently is this caused by bleeding from the nose discharging posteriorly and therefore being swallowed. On the other hand, one must not overlook the fact that bloody vomiting may denote internal injuries, or injuries to the palate or pharynx. In a certain number of cases vomiting is undoubtedly an evidence of increased intracranial pressure. Particularly is this true among those where it is a late manifestation occurring several hours or days after the accident. Children are more frequent sufferers of this complication, as also shown by Beekman and Ireland. Particularly in adults vomiting subsides rather quickly and it is not a constant finding in cases of increasing intracranial pressure due to trauma.

Urinary Incontinence.—Incontinence of urine is seen quite frequently in patients with severe shock and those with severe brain injury. There were forty-one recorded cases among those with proven fracture (7 per cent.). With amelioration of the patient's condition normal evacuation ensues. It is important in cases with urinary disturbances to be sure that the condition is of a cerebral origin rather than spinal. In three patients there was overflow incontinence due to an associated injury to the spinal cord.

Ocular and Extra-ocular Manifestations.—Head injuries are frequently associated with ocular and extra-ocular changes. Contusions, subcutaneous hæmorrhages in the lids, and subconjunctival hæmorrhages are common manifestations. Occasionally the swelling is so marked as to simulate proptosis. Genuine cases of proptosis may also occur, as was true in this series in two patients. One had bilateral chemosis, and proptosis

with a septic temperature, and diagnosis of cavernous sinus thrombosis was made. In another case the patient had a definite proptosis in the left eye with the pupil slightly more dilated on the side of the lesion. Manometric studies in this case revealed that unilateral jugular compression on the left caused no change in spinal-fluid pressure, while on the right a rise of 100 millimetres was noted. It was thought that this patient also suffered from thrombotic condition involving the left cavernous sinus region.

There has been much written concerning pupillary inequality in cases of skull fracture. McCreery and Berry in a study of 512 cases noted forty-one with unequal pupils with thirty-six deaths. Blakesley in a series of 610 cases found 121 with unequal pupils with fifty-three deaths. When the dilated pupil was fixed the prognosis was less favorable. Some have advocated operation in presence of a dilated pupil. (Davis.) It must be emphasized that patients may have unequal pupils before the accident. In this series three patients with this condition had lues, and the inequality was a direct result of the latter disease. There were sixty-one cases of unequal pupils in this group study. Of these thirty-five recovered and several among them had no associated evidences of brain injury. Of the thirty-five only ten were operated on. The dilated pupil is usually on the side of the lesion. Holman and Scott, Rand and others feel that the dilated pupil is always on the side of the lesion, although I am sure this does not obtain in every case. It should also be emphasized that massive hæmorrhage in the brain may not be accompanied by inequality. This was true in several of the autopsy group. Pupillary inequalities may appear and disappear in the course of several hours. At times they are less marked under the action of a bright light. The cause of inequality of pupils is not well known. If there is cerebral representation of pupillary reaction it is possible that with injury to such a region there may be a partial paralysis of the corticotectal fibres associated with the central part of the third nucleus, and with partial paralysis of the latter and overactivity of the sympathetic innervation, a dilated pupil may ensue. It must be remembered, however, that a dilated pupil may denote a peripheral paralysis of the third nerve. If so, there should be associated outward rotation of the eyeball, and with amelioration of the patient, a definite ptosis of the lid. This is particularly true in some cases of middle meningeal hæmorrhage. Elsewhere I have discussed the fact that with an enlarging clot at the base of the middle fossa the contents of the superior orbital fissure may be compressed with consequent paresis of extra-ocular nerves, particularly the oculomotor nerve.

An absence of reaction to light is a serious manifestation, as well brought out by several authors. Stewart notes that in fifty-three cases with dilated and fixed pupils the outcome was fatal. In the McCreery and Berry series there were 168 cases of fixed pupils with 128 deaths. Blakeslee reports fifty-five widely dilated and fixed pupils with fifty-two deaths. However, some of these cases do recover and a hopeless prognosis should not be given on this point alone. Marked dilatation of the pupils is not so serious a sign

in my opinion, particularly if observed soon after the accident; it may be an expression of shock. In these investigations it is important to note the time between accident and such clinical observations. If observed soon after the accident such findings are probably not as serious as when seen several hours afterwards. It is also to be emphasized that to depend on just one clinical finding alone may at times be embarrassing. As a matter of fact, in some of these cases of serious craniocerebral injury, one may prognosticate the case accurately irrespective of pupillary findings.

It is rather difficult to make a diagnosis of extra-ocular palsy in an unconscious, uncoöperative patient. Soon after the accident it is a common occurrence to find the eyes rolled upward, to one side or the other, and in

FIG. 1.

FIG. 2.

FIG. 1.—Third-nerve paralysis due to middle meningeal hæmorrhage. He recovered complete function of this nerve including reaction to light and accommodation of the pupil.

FIG. 2.—Internal strabismus of the right eye (sixth-nerve palsy) with peripheral seventh-nerve paralysis on the same side. The palpebral commissure is wider on the right and the angle of the mouth does not rise as far up as on the left. Patient had fracture involving middle third of the skull.

some cases one sees coarse nystagmoid movements. However, in the absence of conjugate deviation, or the presence of unilateral mal-position, the possibility of an extra-ocular paralysis should be kept in mind. As the patients get better it is easy to note such a paralysis. In this series there were thirteen cases of extra-ocular dysfunction, six had third-nerve and seven had sixth-nerve palsy. In two cases there was thought to be an associated fourth-nerve paralysis due to the fact that in the presence of an oculomotor palsy the eyeball turned only outward instead of out and down. This is rather a coarse method of diagnosing trochlear dysfunction. The accompanying figures show some of these changes. Of particular interest

is Fig. 2, where the patient evidently has a sixth-nerve and a peripheral seventh-nerve paralysis on the same side. Third-nerve palsy was most frequently seen in middle meningeal hæmorrhage. They all recovered completely within four months after the accident. In the latter pupillary reaction to light and accommodation returned. It is possible for the sixth nerve to be injured in the superior orbital fissure, but in this position it is better protected than the third and fourth nerves because of its more peripheral position. In such a case, however, one should see more than sixth-nerve dysfunction. The condition should simulate more the superior orbital fissure syndrome by the implication of the ophthalmic division of the trigeminal nerve or the third nerve, or the fourth nerve, or a combination of all.

TABLE VII

Analysis of Ocular and Extra-ocular Changes in the Series

UNILATERAL BLINDNESS		COMPLETE OCULOMOTOR PALSY		COMPLETE 6TH NERVE PALSY		PROPTOSIS WITH SINUS THROMBOSIS		UNEQUAL PUPIL			
3 CASES		6 CASES		7 CASES		2 CASES		61 CASES			
2	1	REC.	DIED	REC.	DIED	REC.	DIED	REC.		DIED	
		5	1	6	1	1	1	35		26	
OPHTHALMOSCOPIC EXAMINATION NEGATIVE	HEMORRHAGE INTO THE VITRIOUS							OPERATED	NOT OPERATED	OPERATED	NOT OPERATED
								10	25	4	22

An analysis of the ocular and extra-ocular changes in the series. Note that a great many cases with unequal pupils recover on conservative treatment.

It is probably true that in the majority of cases sixth-nerve palsy is due to an involvement of the nerve in its course through the cranial cavity. The two cases I have been able to follow up in this series still have the internal strabismus due to sixth-nerve involvement (ten and fourteen months respectively). Three others have regained practically complete function.

In three cases there was complete blindness. (Table VII.) Two showed no injury to the retina and other contents of the eyeball on ophthalmoscopical examination. In one there were hæmorrhages in the vitreous and he could perceive light about the third week after entrance. The mechanism of blindness in cases where the eyeball is found to be normal is difficult to explain. It is possible to have a fracture in the region of the optic foramen with impact against the nerve and consequent blindness. This, however, could not be severe enough to cause a tear of or pressure against the ophthalmic artery which accompanies the nerve, for examination of the

retina does not show any changes in vascularity of the region soon after the accident. It is also possible to have hæmorrhages in the sheath of the optic nerve with consequent pressure neuritis. Although at first the retina is negative in the course of about three months the nerve head is practically completely atrophic in appearance. In some cases of unilateral blindness it may be worth while to expose the optic region intracranially in order to remove any pieces of bone that may be pressing against the optic nerve in its course through the foramen.

Ophthalmoscopical examination is an important adjunct to our clinical methods in cases of head injury. However, its significance as a measure of degree of intracranial pressure is overestimated according to my findings. Choking of the discs is very infrequent, certainly within the first twenty-four hours. Engorgement of veins as indicative of increasing intracranial pressure is not definite enough a sign to be worthy of consideration. The same degree of engorgement is seen quite frequently in the normal in-

TABLE VIII

Analysis of 138 Cases of Death in the Series

TIME OF DEATH						BLEEDING EARS			CONVULSIONS			OTHER INJURIES				INFECTIONS			
UNDER 3 HRS.	UNDER 6 HRS.	UNDER 12 HRS.	UNDER 24 HRS.	UNDER 48 HRS.	OVER	RIGHT	LEFT	BOTH	JACKSONIAN	GENERALIZED	DORSAL EXTENSION TYPE	FRACTURES ELSEWHERE	CHEST INJURIES	INTRA-ABDOMINAL INJURIES	SPINAL INJURIES	MENINGITIS	SEPTICEMIA	PNEUMONIA	GAS BACILLUS
33	10	18	12	20	45	18	15	20	11	7	5	27	5	11	3	4	7	6	1

Analysis of cases of death in the series. Note that sixty-one cases died within twelve hours after entrance into the hospital. The résumé of injuries elsewhere in the body is instructive. Also consult text on this subject.

dividual. In a certain number of the cases I have seen hæmorrhages in the retina. A case of vitreous hæmorrhage was described in the preceding paragraph. It is my opinion that increased intracranial pressure due to brain injury does not manifest itself in the nerve head but very infrequently, certainly not within the first twenty-four hours. The absence of swelling of the nerve head has not been a criterion for intervention or non-intervention when operative treatment or spinal puncture was contemplated. Only one case of middle meningeal hæmorrhage out of six showed sufficient change in the discs to be called swelling of the same.

BLOOD STUDIES.—At the Receiving Hospital all cases of head injury have blood studies within twelve hours after entrance into the hospital. Routinely white count, red count and differential are procured. Serological studies on the blood are also used.

In cases of craniocerebral injury, particularly in the presence of cerebral damage, there is an associated increase in the white count. The majority of cases show initial counts varying between 12,000 and 18,000. There are

many who show higher counts. There seems to be a direct relation between the white count and the severity of bloody spinal fluid, *i.e.*, bruising and laceration of the cortex. Moody states that counts around 18,000 and 20,000 are suggestive of middle meningeal hæmorrhage. It is true that with extradural clot the white count ranges between 18,000 and 20,000, but there are many such counts with no associated meningeal clot. It may be stated roughly that a high count is in direct ratio with extent of brain damage with hæmorrhage. In this connection it should not be forgotten that shock and hæmorrhage elsewhere may also be productive of high counts. It would be interesting to follow up cases with initial high counts for post-traumatic sequelæ.

Serological studies showed that there were twenty-seven patients with

FIG. 3.—This is to show a middle meningeal clot removed at operation. It weighed eighty-five grams. It illustrates the value of osteoplastic flap in such cases, a method which affords a practically complete removal of the clot. Convalescence after osteoplastic craniotomy in these cases is much shorter.

4 plus Wassermann and Kahn. These patients may show varied neurological changes which should not be attributed to skull fracture. The association of brain damage and lues is quite unfortunate, at least in this series, in that the majority of these patients lingered on in the hospital for long periods, and some were committed to insane asylums.

NEUROLOGICAL CONSIDERATIONS.—Patients with brain injury as a rule manifest clinical changes characteristic of certain localizations. However, it must be emphasized that with an uncoöperative and unconscious patient complete neurological data are not obtainable and, therefore, it is not uncommon to miss brain pathology which is easily localizable in a coöperative patient. While the patient is in a serious state the only system which can be

tested out with accuracy is the motor system. With the amelioration of the patient's condition more data can be obtained for purposes of localization. In the next few paragraphs I propose to discuss the various neurological changes which are obtained in the present series.

Altered States of Consciousness.—Unconsciousness following trauma to the head may be caused by: first, a definite macroscopical or microscopical injury to the central nervous system; second, in the absence of the above it may be due to a change in the electrical potential of nerve cells causing dysfunction of the same (Miller); third, in some cases it may be due to vasomotor changes in the body causing anæmia of the brain as a result of migration of much blood to the splanchnic area. Miller does not think that anæmia of the brain is operative in cases of "concussion" due to blows on the head. McClure and Crawford attribute much significance to the length of the period of unconsciousness and they think that the longer a patient is unconscious the worse are the sequelæ after leaving the hospital.

In the present series there were 102 cases with proven skull fracture who gave no history of unconsciousness. The remainder of the series showed different states of altered consciousness which may roughly be classed as follows: first, those with initial unconsciousness not lasting over two hours and with some evidence of brain dysfunction not lasting over thirty-six hours; second, those with initial unconsciousness followed by definite disorientation lasting for several days; third, those in coma and most usually fatal. Of course, it is understood that a given case may show clinical signs and symptoms characteristic of any of the above groups and lapse into a state characteristic of another.

Of particular interest is the second group, where patients may remain disoriented for weeks. One case was unconscious for over forty days. There were twenty-two patients who had to be transferred to the psychopathic wards because of their mental state; all but two had bloody spinal fluid. A few among them were eventually sent to asylums. In this connection it should be stated that an associated C. N. S. lues is a serious complication. Six among the twenty-two had 4 plus Wassermann on the blood and spinal fluid. It is probably true that psychotic changes are more frequently seen among those with generalized subarachnoid hæmorrhages. The spinal fluid is usually very bloody and repeated lumbar drainage seems to have little effect on the course of their condition. However, it is surprising to note that a certain number, following a discouraging course, seem to recover practically completely.

Cranial Nerves.—In cases of acute craniocerebral injury at least some cranial nerves are frequently implicated. In one case in this series there was olfactory dysfunction due to skull fracture. Such cases have been described by several authors (Naffziger and his literature review, Swift and others). In the acute case it is difficult to test out this nerve; the associated nasal bleeding with its obstructing clots may also be a factor in mistakes in diagnosis. The second, third, fourth and sixth nerves and their dysfunctions

have already been discussed under ocular and extra-ocular changes. The fifth nerve is particularly prone to be injured in its maxillary branch with fractures that involve the upper jaw. Particularly has been the case with depressed fractures of the zygomatic arch. In such cases an anæsthesia in the distribution of the infra-orbital nerve and its ramifications is noted. The first division of the nerve may be involved in association with extra-ocular nerves as they pass through the superior orbital fissure. In one case there was anæsthesia in the ophthalmic distribution of the fifth nerve with complete extra-ocular paralysis and an associated blindness, evidently a case of the syndrome of the superior orbital fissure. The third division of the trigeminal nerve is, of course, usually associated with fractures of the lower jaw, and Dr. Lloyd Rogers, of the Department of Oral Surgery, informs me that it occurs in practically all cases where there is an associated displacement of the fragments. The seventh nerve has already been discussed in relation to blood discharge from the ear. A peripheral seventh-nerve palsy may obtain with no associated bleeding from the ear and I have seen a few such examples. In the Foster Kennedy and Wortis series peripheral facial paralysis was seen much more frequently than is evident in this group. The eighth nerve has also been discussed in relation to bloody discharge from the ear. Excellent papers on this subject are written by Brünner, Linthicum and Rand, Swift and others. According to Vance, actual nerve deafness is most probably permanent if it persists over two months. Dysfunction of the ninth, tenth, eleventh and twelfth nerves is not usually seen in civil practice. However, it is conceivable to have a fracture of the posterior third of the skull with associated involvement of any or all of these nerves. Such a case of multiple nerve lesions including the last four cranial nerves is described by Shemeley. These structures are more frequently involved outside of the cranial cavity by stab or bullet-wounds or tumor in the retromandibular space. Cases of this type have been described by Vernet, Villaret and Faure-Beaulieu, Sicard, Stookey, and others.

Convulsions.—There were forty-six cases with convulsions in the series (6 per cent.). It is unfortunate that all cases with motor-cortex involvement do not show this complication. In the present series only ten cases in a group of forty-two showing clinical manifestations of cortical motor pathology had convulsions. Particularly the Jacksonian type is of important localizing significance. I have classified cases of convulsions into three groups on the basis of type of spell: first, those with Jacksonian epilepsy; second, those whose attacks simulate the usual epileptic fits, and third, those whose attacks are characteristic of decerebrate rigidity. For methodical purposes I will discuss each type of convulsive seizure separately. (Table IX.)

Jacksonian Attacks.—Jacksonian attacks were seen in twenty-three cases. It is interesting to note that more than 50 per cent. recovered. The attacks are characterized by localized clonic and at times tonic movements of functional groups of muscles, such as one side of the face, face and arm, an entire half of

the body, *etc.* In one case I saw Jacksonian epilepsy of the tongue. From a diagnostic standpoint Jacksonian attacks are helpful, in that they most always signify injury to the corresponding motor cortex supplying the area of attack. In this clinic we feel that localized spells are cases for operative treatment when taken in conjunction with other clinical data. In the absence of corroborative clinical findings of hæmorrhage or other localized pathology we watch the patient carefully, being ready at any time to intervene surgically. In this connection it is important to mention that a certain number have attacks soon after injury who, in the course of twenty-four hours, are absolutely conscious and apparently progressing in good shape. In another group of cases Jacksonian spells have been seen as a late manifestation and in the absence of other data to justify an operative approach I have performed lumbar punctures with excellent results. However, on the whole it is true

TABLE IX

Analysis of Cases with Convulsions

JACKSONIAN TYPE		EPILEPTIC TYPE		DORSAL EXTENSION TYPE	
23 CASES		18 CASES		5 CASES	
DIED	RECOVERED	DIED	RECOVERED	DIED	RECOVERED
11	12	7	11	5	0

Analysis of cases with convulsions. Note that decerebrate rigidity type of spells are very serious as concerns prognosis.

that localized spells usually mean operative treatment, although one does not have to hurry in the absence of associated signs and symptoms indicative of localized cerebral pressure. The use of lumbar puncture in some of these cases is inestimable.

Epileptiform Attacks.—Epileptiform convulsions were seen in eighteen cases. These attacks are characterized by the usual frothing at the mouth, occasional biting of the tongue, and tonic and clonic spasms involving the entire body. A few of these cases were epileptics to start with and this possibility should always be kept in mind when observing such a spell in cases of skull fracture. I think that in most cases of generalized convulsions conservatism is the proper procedure, in the absence of localizing signs. Here also lumbar punctures are invaluable. It should be emphasized, however, that Jacksonian spells may eventuate in generalized convulsions, the latter manifestation probably being due to the associated increased intracranial pressure and traumatic encephalitis. Of eighteen cases showing this complication only seven succumbed.

Decerebrate Rigidity Type of Attacks.—I have seen five cases of convulsions characterized by tonic contraction of the entire body musculature, particularly the trunk and lower extremities, so much so that these parts of the body form an arch with convexity upward with the body in the recumbent position. The upper limbs also showed some contractures to a great extent characteristic of decerebrate rigidity. It is the sort of convulsion seen in children with chronic basal meningitis. Associated with this extreme tonic convulsion of the body musculature (dorsal extension type), some cases also showed a few clonic spasms of functional muscle groups. This type of convulsion has always been fatal in this series. They all had spinal fluid with very high blood content and evidences of bilateral pyramidal-tract irritation. I wonder if such attacks may be an expression of irritation of the brain stem due to the irritating influence of blood in the ventricular system, and associated traumatic encephalitis.

TABLE X

Some of the Focal Manifestations in the Series

RIGHT HEMIPLEGIA	LEFT HEMIPLEGIA	MONOPLEGIA		PARAPLEGIA		TRIPLEGIA	APHASIA	CATATONIA	RESULTS				CONVULSIONS
		UPPER	LOWER	UPPER	LOWER				DIED		RECOVERED		CASES
13	11	4	1	0	3	2	8	5	OPERATED	NON-OPERATED	OPERATED	NON-OPERATED	10
									8	11	9	12	

An analysis of some of the focal manifestations in the series. Note that a great many recover without operation.

OTHER CORTICAL AND SUBCORTICAL MANIFESTATIONS.—Table X shows the number and type of changes recorded in the series. By far the majority showed hemiplegia. There were thirteen cases with right-sided and eleven cases with left-sided paralysis. In one case the right-sided hemiplegia was the result of hæmorrhage due to rupture of the lenticulo-striate artery in a patient fifty-four years of age. Monoplegia was seen in five cases. Lower extremity paraplegia was seen in two cases, and it was a result of tangential fractures along the vertex. Two cases had triplegia, one due to extradural clot, and the other due to a tangential fracture. Aphasia was studied in eight cases. Among these seven had the usual right-sided paresis and one had a pure aphasia associated with catatonia. Catatonic states were noted in five cases. Only ten patients in the entire group of forty-two showed irritative manifestations, *i.e.*, convulsions. Of these eight had Jacksonian epilepsy, one generalized convulsions and one spells of the dorsal extension type. In the next few paragraphs consideration will be given some of these above findings.

The Syndrome of the Superior Longitudinal Sinus.—In 1914, Holmes

and Sargent described the syndrome of the superior longitudinal sinus. They brought out the fact that tangential fractures involving the convexity of the vault near the mid-line were associated with paresis of the lower extremities with also a possible involvement of one of the upper limbs. The pathology was that of either destruction of the lower extremity centres near the mid-line from the fracture or a destruction of the blood supply from the same region due to thrombosis of the superior longitudinal sinus. Willensky, Levi-Valensi and Ezes, and others have described cases of this type occurring in civil practice. In four cases of this series such a diagnosis could be made both on clinical and pathological grounds. One which came to autopsy showed a marked rigidity of the lower limbs. There was a perforating wound passing through the superior longitudinal sinus, causing a large clot between the two hemispheres and over the corpus callosum. Another case had a depressed fracture in the interparietal region with rigidity of the lower limbs. A third case came in about six weeks after the accident with a depression in the interparietal region. He had severe sensory and motor changes in the leg and foot on the one side with some motor changes in the opposite limb. The depression was removed and soon after the patient was much better. Three months after operation he stated that he was practically normal. The fourth case was that of a middle meningeal hæmorrhage which had dissected its way between the dura and the bone over the convexity of the hemisphere, extending over the mid-line where there was a large globular mass of blood pressing against the lower extremity centres on both sides. This patient had bilateral Babinski, ankle and patellar clonus with a dilated pupil and evidence of third-nerve paralysis on the right side. It was easy to explain the clinical findings following operation and following the finding of a large blood clot across the mid-line in the posterior parietal region. The diagnosis of superior longitudinal sinus syndrome should be kept in mind in the presence of increased reflexes and rigidities involving both lower limbs. Such a conclusion may materially alter the method of treatment in the case.

Catatonic States in Skull Fractures.—Gowers discusses the possibility of catatonia following blows on the head. Kleist did much work on the relation of catatonia and aphasia and is of the opinion that catatonia may be a pyramidal dysfunction. Wilson feels that catatonia may be due to lesions of the pyramidal system. Vogt, Hoff and Schilder, Dejerine, Lewy and Urechia discuss the association of catatonic states with striatal and cerebellar diseases. In the Journal of Nervous and Mental Diseases, 1931, I described two cases of catatonic rigidity due to skull fracture with brain injury. I am now able to add three more cases, two in adults and one in a child four years of age. One of these patients, an adult of twenty-seven, had a fracture in the left parietal region with definite evidences of aphasia and catatonic rigidity of all four extremities. It is interesting to note that in this case following a lumbar puncture which yielded clear spinal fluid the patient instantly was capable of speech and his catatonia also disappeared, to reappear in a few hours in a milder form. The second adult was a patient of thirty-eight with

fracture particularly in the left parietal region and also crossing the mid-line and extending into the right parietal. He had a marked aphasia of the motor speech type with a very definite catatonia involving all four limbs. His catatonic condition disappeared before the aphasia which lasted in a milder form four or five weeks. This patient could be placed in the most bizarre positions with no apparent fatigue. The third case, a child of about four years of age, had no skull fracture by ray, but was unconscious for several hours following a blow on the head. He had a dissecting hematoma between the scalp and the bone which apparently filled practically the entire sub-aponeurotic space of the head. This child had definite evidences of catatonia.

The association of catatonic states with aphasia in cases of skull fracture with brain injury is outstanding. In the previous communication it was noted that such states in cases of skull fracture in association with aphasia are most probably of cortical origin. I still cling to this conclusion and, furthermore, I feel that in an unconscious patient the presence of catatonia is most probably indicative of a lesion in the left fronto-parietal region of the cortex. It is possible that with the destruction of the correlative motor centres on the left side there may be associated inability to gauge the extent of movement of a certain part in the production of a certain complex movement with consequent result of catatonic rigidities. It is also possible that with the destruction of such centres which may be located in close proximity to the speech centres there may be an inability to properly correlate the individual components of a complex movement so that when the patient has a limb placed in a certain position he has a lack of the ability of correlation of components of the complex movement of allowing that limb to go back to the normal resting state. I think catatonic states should be looked for in cases of brain injury and I am sure that in a certain number of cases they will be discovered. Further observations may enable one to prove definitely whether or not they have a localizing significance as suggested above.

The Diagnosis of Laceration of Orbital Surface of Frontal Lobes.—In a previous communication in the Archives of Neurology and Psychiatry on the subject of diagnosis of lacerations of the orbital convolutions of the frontal lobe, I brought out the fact that such lacerations may be diagnosed before death, at least in a certain number of the cases. It is true that a large majority of skull-fracture cases coming to autopsy show contrecoup lacerations in this situation. It is also true that the orbital surface of the frontal lobe is essentially a silent area except its extreme posterolateral portion, which is continuous with the lower end of the Sylvian fissure. In cases of contrecoup damage to the orbital surface of the frontal lobes there is an added damage to the tip of the temporal pole and the lower end of the Sylvian fissure by virtue of the presence of the sharp posterior margin of the lesser wing of the sphenoid bone. With involvement of the lower end of the Sylvian fissure there may be motor phenomena in the opposite half of the body particularly involving the face and possibly also the upper limb. These may be irritative in nature such as Jacksonian epilepsy of the face and upper limb or paralytic

such as cortical facial paralysis and increased tendon reflexes in the upper limb on the opposite side. It is probably true that in the absence of localized depressions pressing against the face centre, Jacksonian epilepsy of the face denotes a more extensive lesion than one involving the region of the face centre alone, particularly in cases of contrecoup damage. In such cases, given a patient in coma with bloody spinal fluid and a fracture in the posterior half of the skull, it can be assumed that the irritative or paralytic phenomena involving the face are of orbital frontal damage significance. For it is true that in cases of skull fracture with brain injury particularly with contrecoup lesions the damage is more regional in character rather than localized, such as caused by a knife, a small tumor, or a bullet. The diagnosis of such lacerations can be made in some of the cases after a careful study of the patient and after due consideration is given to every finding in the physical examination. The position of the fracture, particularly if it involves the posterior third of the skull, the spinal-fluid findings which should be bloody, and the presence of Jacksonian epilepsy of the face or also the upper limb in the absence of localized depressions over the motor centres should make one suspect such lesions. In one case with an extensive compound depression in the left frontoparietal region such lacerations were seen at operation, and the only manifestation of a motor nature the patient had was cortical facial weakness on the opposite side. This patient recovered.

Alternating Oculomotor Paralysis in Middle Meningeal Hæmorrhage.—In a certain number of cases with middle meningeal hæmorrhage there is a syndrome similar to that described by Weber and of mid-brain significance. In a previous paper appearing in the Archives of Neurology and Psychiatry I described this similarity and gave several examples. It was thought that oculomotor paralysis in these cases was due to pressure against the contents of the superior orbital fissure and the cavernous sinus. It is true that extra-ocular paralyses have previously been described in cases of middle meningeal hæmorrhage. But the association of an extra-ocular paralysis (particularly the third nerve) with contralateral paralysis of the body reminds one of Weber's syndrome. The contralateral paralysis is undoubtededly due to pressure against the motor cortex by the enlarging clot. In one case there was an associated proptosis of the affected side most probably due to sufficient pressure to cause an engorgement of veins of the orbit by virtue of pressure against the cavernous sinus. There were six cases of middle meningeal hæmorrhage diagnosed in the series, four of which showed the alternating oculomotor paralysis. Of these six, four recovered and they were all operated on. Of the fatal two one was not operated, and the other underwent surgical procedure, but he succumbed, undoubtedly to associated brain damage which the autopsy showed. In his case there was a large intracerebral clot in the temporal pole on the same side with laceration of the orbital convolutions of the frontal lobe on the opposite side. His fracture was confined to the posterior third of the skull, and apparently damaged the posterior branch of the meningeal artery. In all but one there was a history

of lucid period. With the exception of the one whose autopsy report is recorded above, they all had temperatures varying from 99° to 102°.

A word concerning the incidence of middle meningeal hæmorrhage in this series would be apropos. It is true that the incidence of middle meningeal hæmorrhage in various morgue series reported in the literature is high (Moody, Vance, McCreery and Berry, and others). Possibly this may be due to the fact that a larger number of them are picked up on streets or in homes, and therefore were unrecognized. But in hospital practice the number of middle meningeal cases is indeed small, possibly because conservatism is in vogue at the present time. In sixty-one consecutively autopsied cases in this series there were only two with middle meningeal hæmorrhage and one of these was operated on, so that the frequency of middle meningeal hæmorrhage, at least in this series, could not be very high when one also considers that in a great many of the fatal cases the pathology was evident (compound fracture, meningitis, infections in other parts of the body, lacerations and bruises of the cortex).

Pathology and Mortality.—Excellent papers have been written on the pathological changes found in cases of head injury. From a study of the contributions of Apfelbach, Le Count and Apfelbach, Stewart, Bagley, Vance, Cassassa, Martland and Beling and conclusions derived from the present series, the following tabulation was compiled:

I. Fracture of the skull, simple.
II. Fracture of the skull, simple depressed.
III. Fracture of the skull, compound.
IV. Intracranial hæmorrhage.
  A. Extradural, due to rupture of meningeal vessels, sinuses and diploe.
  B. Intradural, due to pial tears, bruises or laceration of nervous tissue.
    (1) Subarachnoid.
      a. Generalized.
      b. Localized.
    (2) Intraparenchymatous.
      a. Petichial.
      b. Massive.
V. Bruising or laceration of nervous tissue, with or without fracture of the skull.
VI. Increased intracranial pressure.
  A. Caused by any of the above.
  B. With no demonstrable brain pathology.
VII. Complications.
  A. Meningitis.
  B. Meningo-encephalitis.
  C. Brain abscess.
  D. Pneumocephalus.

It is not the purpose of the present few paragraphs to go into extensive detail as concerns the pathology in cases of head injury. The above tabulation is a helpful clinico-pathological compilation, which would remind one of all the various possibilities when treating a case of craniocerebral injury. It is to be emphasized, of course, that a good knowledge of the pathological

changes is the only sound criterion in the treatment of such cases. A glance at the above tabulation shows that as physicians we are helpless in the presence of several conditions, at least for the present. It seems reasonable to operate on cases of compound fracture, depressed fracture with signs, and cases with extradural hæmorrhage. (Table XI.) In patients with subarachnoid hæmorrhage, particularly when it is generalized with clots over the entire one or both hemispheres, I wonder if any operative procedure is at all efficacious? The rationale of subtemporal decompression is not well understood. Through an opening in the temporal fossa only a very small fraction of the hæmorrhage is brought to light. Unless the operation is done for combating increased intracranial pressure, it has practically no place in the treatment of the case in so far as future results are concerned. The same reasoning may be carried on as concerns intraparenchymatous hæmorrhages

TABLE XI

Analysis of Operations—51 Cases

SIMPLE DEPRESSIONS		COMPOUND DEPRESSIONS		MIDDLE MENINGEAL HEMORRHAGE		SUBDURAL HEMORRHAGE WITHOUT DEPRESSION		ENCEPHALOGRAM		PLASTIC FOR PNEUMOCEPHALUS	
24 CASES		10 CASES		5 CASES		8 CASES		3 CASES		1 CASE	
REC.	DIED	REC.	DIED	REC.	DIED	REC.	DIED	REC.	DIED	REC.	DIED
16	8	8	2	4	1	2	6	3	0	0	1

Analysis of operations in the series.

or bruises and lacerations of nervous tissue. Here again operative approach seems quite unreasonable particularly with petichial hæmorrhages and contusions of the cortex and in cases of laceration of the brain it may make matters worse. This is essentially true except if the operation is used to save the life of the patient. However, it is, of course, conceded that in some cases where the clinical findings point to a progressive lesion operative intervention is the only course we have. It seems that the more one thinks of the pathology in some cases of craniocerebral injury the more he believes in the conservative treatment of the same.

Although lumbar drainage is an important therapeutic agent in brain injury work at present, a glance at the above tabulation shows the limitations of the procedure, particularly as concern late results. If it is true that the presence of blood in the subarachnoid space is productive of inflammatory changes, this result must be brought about within the first few days, for we know that after bleeding is stopped the spinal fluid becomes clear again within about a week. It is reasonable to assume, therefore, that the presence of blood

in the subarachnoid space lays the foundation for the so-called late manifestations within the first few days. It is also known that even in clinics rabid on lumbar drainage in cases of brain injury only small amounts of spinal fluid are removed during the first few days, so that sufficient amount of blood remains in the subarachnoid space to do its devastating work. Matters are much worse in the presence of sufficiently large amounts of blood in the subarachnoid space causing the formation of clots over the cerebral sulci. Under such conditions lumbar puncture cannot remove the clots from over the hemisphere, and organization and absorption must go on irrespective of lumbar drainage. It seems to me that lumbar punctures are of greater immediate therapeutic value by virtue of control of intracranial pressure. It is unnecessary, I believe, to go on further and note that in so far as the future of the patient is concerned lumbar punctures cannot appreciably change the outcome in cases of laceration and bruises of the cortex, intraparenchymatous hæmorrhages, *etc.*, except if they are used to combat the intracranial pressure and thus minimize further damage by controlling the progressive swelling of nervous tissue.

In cases of skull fracture with brain injury one should not forget the possibility of co-existent pathology in other parts of the body. It must be emphasized that patients with injuries to the head receive the same in accidents which may injure any part of the body. In the present series among those with fatal termination there were twenty-seven cases with fractures elsewhere in the body, six cases with evident chest injury, ten cases with intra-abdominal injury, (ruptured spleen, two cases; ruptured liver, two cases; retroperitoneal hæmorrhages, six cases), three patients had associated spinal-column damage with transverse myelitis. It is conceded that most of these patients would have probably died with no associated head trauma. The combination of head injury and intra-abdominal injury is a serious one, in that the usual signs and symptoms referable to the abdomen are lacking due to the depressed state of the body. It is important in head injuries to have complete autopsies and in speaking of mortality in clinical groups it is important to know whether or not there were associated injuries elsewhere in the body. People (at times like myself) who review head injury series entering the institution before their time are confronted with a serious handicap particularly if their records are not complete. (Table VIII.)

In the present series there were eighty-nine cases of head injury who had associated injury to other parts of the body, or who may have died other than a skull death. They may be grouped in one paragraph as follows:

(1) Shot in the abdomen and head, recovered; (2) rupture of spleen, died; (3) fracture of lower jaw, recovered; (4) fractured leg, recovered; (5) fractured femur, tender and rigid abdomen, died; (6) fractured ribs, clavicle and subcutaneous emphysema, died; (7) fractured lower jaw, recovered; (8) fracture of both legs, and right wrist, laceration of elbow with ensuing cellulitis and septicæmia, died; (9) fractured femur, recovered; (10) fractured clavicle, recovered; (11) fractured lower jaw, died; (12) frac-

tured ribs and clavicle, recovered; (13) compound fracture of both legs with gas gangrene, died; (14) ruptured bladder, recovered; (15) ruptured kidney, recovered; (16) fracture of both clavicles, recovered; (17) crushing injury of one upper limb, the entire limb had to be amputated, died; (18) fractured ribs, recovered; (19) fractured femur, recovered; (20) fractured lower jaw, recovered; (21) fractured ribs, recovered; (22) fractured humerus, died; (23) puncture wound (ice pick) of pericardium with purulent pericarditis, recovered; (24) fractured pelvis and clavicle, recovered; (25) fractured leg, recovered; (26) fractured ribs, recovered; (27) fractured clavicle, recovered; (28) fractured clavicle, recovered; (29) peritonitis due to internal injuries, died; (30) fractured femur, recovered; (31) compound fracture of elbow and forearm, died; (32) fractured leg, recovered; (33) compound fractured tibia, died; (34) fracture-dislocation of cervical vertebræ with transverse myelitis, died; (35) fractured forearm, recovered; (36) fractured mandible and clavicle, recovered; (37) fractured clavicle, recovered; (38) fracture of both femurs, recovered; (39) fractured humerus, recovered; (40) fractured pelvis and bleeding from the vagina, died; (41) compound fracture of leg, died; (42) internal injuries, died; (43) fracture of both legs, fractured ribs, laceration of chest wall, with protruding lung, died; (44) fractured scapula and both hands, recovered; (45) fractured ribs, recovered; (46) fractured humerus, died; (47) fractured ribs, recovered; (48) fractured wrist, died; (49) fractured leg, died; (50) shot in both head and abdomen, died; (51) compound fracture of leg, died; (52) ruptured spleen, died; (53) ruptured liver, died; (54) compound fracture of leg, died; (55) fractured femur, and infected laceration of arm with cellulitis and septicæmia, died; (56) fractured ribs, subcutaneous emphysema, died; (57) fractured leg, died; (58) fractured ribs, followed by lobar pneumonia, died; (59) fractured ribs, improved; (60) fractured wrist, recovered; (61) fractured pelvis, recovered; (62) fractured femur, died; (63) fractured clavicle, recovered; (64) fractured ribs and internal injuries, died; (65) fractured femur, died; (66) fractured scapula and mandible, recovered; (67) fractured scapula, recovered; (68) fractured legs, recovered; (69) compound fracture of elbow, recovered; (70) fractured ribs, recovered; (71) fractured femur, recovered; (72) fractured clavicle, recovered; (73) fractured mandible, recovered; (74) fractured legs, died; (75) fractured pelvis, fracture-dislocation lumbar spine, died; (76) fractured leg, recovered; (77) fractured mandible, recovered; (78) fractured ribs, clavicle and humerus, recovered; (79) fractured clavicle, recovered; (80) fractured clavicle, recovered; (81) fractured femur, recovered; (82) fractured leg, recovered; (83) fractured leg, recovered; (84) fractured ribs, pneumothorax, lung collapse, lung abscess, compound fracture forearm, fractured leg, fractured pelvis, retroperitoneal hæmorrhages, died; (85) dislocation of femur, recovered; (86) fractured ribs, recovered; (87) fractured jaw, recovered; (88) apoplexy, died; (89) fracture-dislocation cervical vertebræ with transverse myelitis, died.

In the present series of 718 cases there were 138 deaths. The mortality

in the entire group irrespective of associated injuries contributory to death is around 19 per cent. Among those where a fracture of the skull was demonstrated there were 132 deaths giving a mortality of around 25½ per cent.* Fifty-one cases were operated on with eighteen deaths. The operative mortality is therefore around 37.5 per cent., leaving out of the total group the cases where encephalography was resorted to.

The complications of head injury as stated above are meningo-encephalitis, brain abscess and pneumocephalus. (Fig. 4.) In this series there were five cases of meningitis with four deaths. The one recovery followed repeated lumbar punctures. The organism isolated was a strep with the characteristics of Koch-Weeks bacillus. For purposes of drainage lumbar puncture is satisfactory except where there is block. Only under such circumstances is one justified to resort to operative ventricular or cisternal drainage. Pregl's septoiod by the carotid route was not used in this series. Crawford states that the results obtained in different clinics justify its use in such cases. It is probably true that infection of the middle ear and the mastoid is the most frequent cause of meningitis in cases of head injury. In the Vance series the paranasal sinus infections were next in order. In the present study there were three cases of otitis media of which two developed mastoid infection. Meningitis followed bleeding ears in two cases, and paranasal involvement in three cases.

There were two cases of aërocele of the frontal sinus and one case of genuine pneumocephalus. The latter was caused by a compound fracture in the posterior third of the skull near the external occipital protuberance. There was cerebrospinal fluid leakage at the site of damage. X-rays showed air in the ventricles. She was operated on, the area of depression exposed, the wound débrided and a three-layer repair obtained. Unfortunately, the wound opened within forty-eight hours. A second attempt at the repair was fruitless. The patient died of meningo-encephalitis. Pneumocephalus complicating skull fracture is at present a fairly common observation, undoubtedly due to the routine use of rays in cases of head injury. Several papers have

* In 475 cases the position was verified by inspection, ray or autopsy. An additional twenty-eight deaths occurred in the series who were neither rayed nor autopsied but they did show various clinical evidences associated with skull fracture. In twelve cases with bleeding from the ear the rays were negative and the patients recovered so that the presence of fracture could not be ascertained. Bleeding from the ear is usually considered a positive evidence of skull fracture and this is undoubtedly true in the greatest majority of cases. However, in the present series one case of unilateral bleeding who also had bloody spinal fluid did not show a fracture at autopsy. Therefore, ruptured drum membrane does not always signify a fracture of the skull in these cases. To the total of 515 may also be added four cases with bloody spinal fluid who were transferred to other institutions before rays could be procured. It is, therefore, evident that 519 cases can be justly grouped under the classification of skull fracture.

Among those who died there were five cases with bloody spinal fluid who showed no fracture of the skull. One case of fracture dislocation of cervical vertebræ showed clinical evidences of brain dysfunction with no associated fracture of the cranium. This leaves 132 cases. Of this group, only among 104 the position of the fracture was verified.

been written on the subject, among those being the contributions of Dandy, Bromberg, Winterstein, Miller, Klemme, and Snoke, and others. Many cases have been treated conservatively with good results. However, in selected cases operative repair is undoubtedly the logical procedure.

TREATMENT.—When one follows the fatal cases to the autopsy room one is impressed by the fact that in a great many no present-day method of approach, whether it be conservative or operative, is of any avail. This is true in some cases with generalized bruising of the brain, general subarachnoid hæmorrhage, contrecoup laceration of the frontal lobes, large intraparenchym-

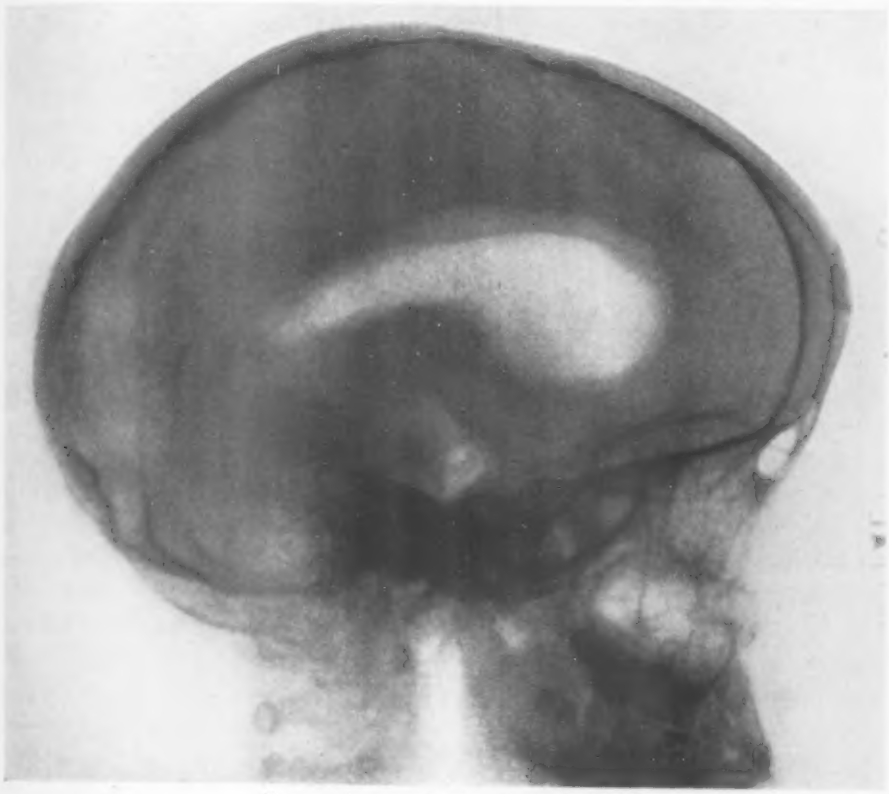


FIG. 4.—An example of pneumocephalus.

atous hæmorrhages, extreme degrees of intracranial pressure, *etc.* It is true that with present-day therapy a certain number of head injuries will die on entrance or soon after entrance into the hospital. There is little to be hoped for in this group, although close scrutiny and careful selection may save a very few among them.

Treatment of skull fracture and head injuries has been ably discussed by several investigators (Kocher, Quincke, Jackson, Stewart, Sachs, Bower, Munro, Peet, McClure and Crawford, Fay, Mock, Ireland, and many others). In the next few paragraphs I propose to discuss as briefly as possible the treatment instituted in cases of head injury in the Receiving hospital. Through-

out this paper in the discussion of specific complications suggestions have been given as concerns treatment.

On the basis of treatment received the present series of 718 cases may be roughly grouped into three classes: First, those patients who were confined to bed with the head of the bed elevated, ice bag applied to the head, fluid intake restricted and where concentrated solutions of magnesium sulphate were given by rectum for three days or longer. This comprised a little over half of the cases and they were kept in the hospital not less than twelve days. Second, those who had added treatment to relieve increased intracranial pressure by the administration of intravenous glucose (50 per cent.) and spinal drainage. This comprised a little less than 40 per cent. of the cases. Third, those where in addition to conservative relief of intracranial pressure operative intervention was also effected. This constituted about 7 per cent. of the series. On the whole the mode of treatment in this hospital for the past five years has been essentially the same as prescribed by Mock in his excellent paper on the treatment of skull fracture. Special emphasis is laid, as pointed out by several authors, on the treatment of traumatic shock in cases of head injury at entrance into the hospital.

Much has been written about the administration of various drugs in the treatment of increased intracranial pressure. I find 50 per cent. glucose (Weed and McKibben, Peet and others) in 100 cubic centimetre doses administered every eight hours superior to various other concentrated salts such as sodium chloride solutions intravenously, magnesium sulphate solutions by mouth or rectum. Glucose solutions are doubly helpful in that they furnish the patient with a certain number of calories helpful in maintaining metabolism. Particularly during the state of shock concentrated solutions of glucose and intravenous saline have been helpful in maintaining the fluid balance and at the same time checking the increasing intracranial pressure. As stated above, the patients are carefully watched for the amount of fluid intake and to insure that they receive about 1,000 cubic centimetres daily, supplemental subcutaneous infusions are also administered. Excessive dehydration is serious and the patients should have sufficient fluid to sustain fairly normal metabolism. I am not familiar with the use of caffeine sodium benzoate as an agent to combat increased intracranial pressure, which Kennedy and Wortis suggest. It is used quite frequently in patients soon after entrance into the hospital to help circulation and the heart.

A few words about lumbar puncture in cases of head injury. This is an important diagnostic and therapeutic procedure. Lumbar drainage should never be done before a careful study of the patient, for the indiscriminate use of this may cause mistakes in diagnosis and possibly undesirable results in some cases, such as in patients with extradural clot, and those with active bleeding from the brain. If it is true that the presence of blood in the subarachnoid space is productive of inflammatory reaction lumbar puncture becomes doubly important in minimizing such an outcome for the patient in the future, although it is questionable that lumbar drainage as it is usually

performed (fractional drainage) does actually remove all of the irritating factor (blood). Much depends on the amount of blood in the subarachnoid space. If there is sufficient bleeding to cause the formation of clots over the cerebral sulci, spinal puncture in such cases cannot afford a complete removal of blood and its products from the subarachnoid space. The blood removed by drainage is what there exists in the cerebrospinal fluid, in suspension. Repeated lumbar punctures do not cause clotted blood to go into suspension in the spinal fluid. At least this is the only conclusion one can arrive at after exploring cases with subdural hæmorrhage. In such cases even though repeated lumbar punctures were performed before operation clots were found over the cerebral cortex. It is therefore to be assumed that lumbar drainage is limited in cases of extensive subarachnoid hæmorrhage in so far as complete removal of blood (irritating factor) from over the hemispheres is concerned. Undoubtedly, in such cases, organization takes place just the same, irrespective of lumbar puncture.

Particularly if performed on a patient soon after entrance into the hospital, lumbar puncture should be done carefully and always with a manometer, as Fay stresses. Soon after injury its administration may be serious in that it may cause further hæmorrhage and further increase in intracranial pressure. In this series I have seen three deaths following soon after lumbar puncture. Unless it is done for diagnostic purposes spinal punctures are not performed in this clinic only after six to eight hours following the accident. The reasons for this are evident. Particularly in serious cases shock must be disposed of first. In a case of active bleeding from the brain lumbar puncture may cause further hæmorrhage by decompressing the organ. Among those whose death occurs within six hours after entrance I doubt if lumbar puncture can alter the situation. In some cases where it is necessary for differential diagnostic purposes, punctures may be performed, but in the majority this will not be needed, for the clinical manifestations are evident.

In some cases with fractured pelvis, fractured lower extremity bones, *etc.*, I have resorted to cysterna punctures. Here again I use the manometer and allow the escape of sufficient fluid to bring the pressure down twenty-five to seventy-five millimetres of water. In this series cysterna punctures were done in eleven cases. It is really simpler than spinal puncture and may be performed with more ease.

Immediate therapeutic results with lumbar puncture in some cases of head injury are remarkable. The period of unconsciousness is lessened in many cases. In some patients with convulsions lumbar drainage has supplanted operative approach in this series. Two cases of aphasia were treated by drainage with marked improvement in the ability to speak soon after the procedure. One case of meningitis was cured with repeated lumbar punctures. There is no question about the usefulness of this procedure in selected cases, particularly for immediate therapeutic results. However, I question its efficacy as a factor in minimizing the undesirable post-traumatic sequelæ in all cases of head injury. Certainly it is not the blood alone in the

subarachnoid space that causes adhesive changes involving the lepto meninges. Many cases of head injury have lacerations of the central nervous system, small intraparenchymatous hæmorrhages, bruises and contusions of the brain which cannot be remedied by any amount of lumbar drainage except if the latter were used for its immediate therapeutic results. (Also see p. 354.)

Operations.—There were fifty-one cases operated on in this series. Of these the majority belongs to the group of simple depressions. Of the twenty-four simple depressions a great many had serious brain damage. Two had rupture of the longitudinal sinus, one had brain abscess, two had severe contusion of the cortex with subarachnoid hæmorrhage, two died of associated septicæmia. Most of the remaining seventeen were asymptomatic or slightly symptomatic simple depressions. There were ten cases operated on for compound depressions, with eight recoveries. All but two were closed tightly at the conclusion of the operation. Two cases with frontal compound fractures were packed according to the method of Peet to hold the dura against the brain in the area of laceration. There were five cases of middle meningeal hæmorrhage, with four recoveries and one death. Eight patients were operated on who showed focal symptoms and at operation generalized subarachnoid hæmorrhage was discovered. Of these six died and two had very stormy convalescence. They were both in the hospital for over two months, one was discharged to an asylum and the other left for home, both in very definitely deranged mental state. Cases of subarachnoid hæmorrhage with localizing signs in this series have been very discouraging as concerns post-operative result. Three patients were subjected to encephalography.

When to operate in cases of skull fracture is a question answered in many contributions. At present the answer is more or less standard as concerns certain lesions. For methodical purposes I should like to discuss under separate heading the various types of lesions where operation is considered the best approach to the problem.

Compound Fractures.—These are truly emergency cases in skull fracture work. Particularly those with depressions are operated on as soon as the patient's condition permits. It is very important to allow them to recover sufficiently from shock and other depressing factors. After all, operating on the patient and having the latter die on the table or soon after is defeating one's purpose even though it may be considered the correct dogmatic procedure. In two patients I waited eighteen and twenty-six hours respectively before operation, and after thorough débridement both were closed tightly. (Figs. 5 and 6.) They both recovered. Particularly when working in the frontal region it may be worth while to keep in mind the removal of the depressed area *en bloc* so that post-operative deformities may be at a minimum. Following careful cleansing and adjustment, the piece may be replaced. The type of incision depends entirely on the type of laceration and its extent. In some cases the tripod incision that Cushing describes in his consideration of war wounds is excellent. In others where the skin laceration is more or less a puncture wound the flap incision may be more profitable. The ideal in

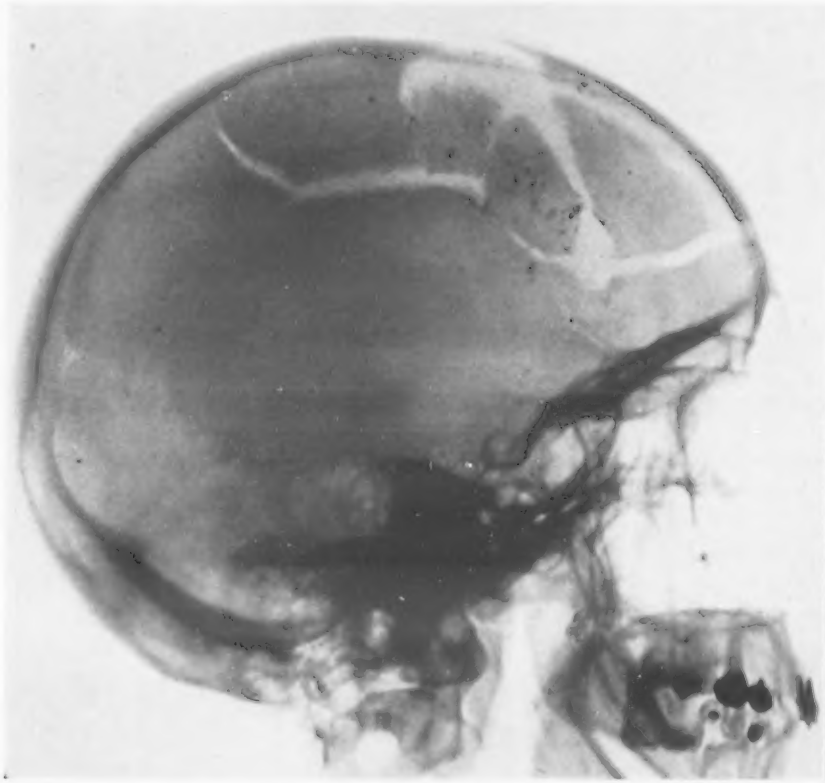


FIG. 5.

FIG. 6.

FIGS. 5 and 6.—Gunshot wound of the skull. These radiographs show the value of conserving all pieces of bone and replacing them before closure. Patient was operated on eighteen hours after entrance. The wound was closed without drainage. At present the contour of the forehead is good.

treating compound fractures is first to prevent infection, and second, and not at all unimportant, to give the patient as little deformity as is compatible with careful work. I try to close all cases without drainage if possible.

Simple Depression.—A majority of simple depressions are practically asymptomatic. If asymptomatic they are not considered emergency cases and need not be operated on immediately. Particularly slight depressions with no symptoms are left to the patient's wish in so far as an operation is concerned. It is surprising to note that a great many depressed fractures remain free of symptoms for long periods of time, so much so that one doubts the necessity for elevation of asymptomatic depressions. It seems that there is a great deal to the experimental findings of Naffziger and Glaser, where they state that injury to the brain with depressed fractures occurs at the time of the accident, that the presence of a depression as such with no initial brain injury is not productive of brain dysfunction. Possibly this may not be true in cases where pieces of bone actually pierce the dura and the brain and their presence in such a position may be productive of more connective tissue than would be the case if these were removed. At any rate, it is important to study the X-rays in these cases carefully, and after thorough study of the patient clinically one can arrive at a sane conclusion as to the proper procedure. Where an operation is undertaken for a simple depression, particularly in the region of the forehead, it is important to keep in mind the values of bloc trepanation. This method is of greater value in simple depressions as compared with those where there is an overlying laceration of the skin. Following the removal of the entire area of depression *en bloc* and readjustment of the depressed pieces, the piece of bone may be replaced with better eventual æsthetic results. I prefer the flap incision in these cases.

Particularly with depressions in the forehead region, block anæsthesia may be used. A few cubic centimetres of 2 per cent. novocaine solution injected in the supra-orbital notch or foramen on both sides with additional infiltration in the area between these two landmarks will anæsthetize the area of distribution of the supra-orbital and the supratrochlear nerves. If the lesion extends far enough laterally the auriculotemporal branch of the trigeminal nerve may also be blocked.

Extradural Hæmorrhage.—A majority of these are cases with middle meningeal hæmorrhage. I have seen two cases of lateral sinus rupture with an extradural hæmorrhage in the posterior third of the skull. The diagnosis of the latter condition seems difficult on clinical grounds. Possibly one may suspect such a lesion by a study of X-rays, presence of depressions in the occipital bone, *etc.* Cases of middle meningeal hæmorrhage are considered fit for emergency treatment in this Institution. In the typical case they are operated on many hours after the accident because of a lucid period which is usually twelve hours or more. In the presence of associated brain damage the lucid period may be totally absent. In cases of middle meningeal hæmorrhage I prefer an osteoplastic flap. However, before this is done a diagnostic trephine hole is made in one or two places in the line of the osteoplastic incision to verify the presence of an extradural clot. After verification I pro-

ceed with the flap operation. In the presence of a lucid period it is probably not necessary to open the dura, but if the patient has been in a serious condition throughout and the dura bulges following the removal of the extradural clot it is advisable to incise the dura, for in a certain number of cases, with meningeal rupture there may be associated intracerebral hematomata in the same sided temporal pole of the hemisphere. The convalescence in cases of extradural hæmorrhage is much shorter with a flap operation and in this clinic we prefer it to the operation of subtemporal decompression. Where it is impossible to do the flap operation due to the presence of lacerations subtemporal decompression may be performed. I usually leave a drain in the epidural space which is removed the following day.

Subdural Hæmorrhage.—Cases of subdural hæmorrhage with progressive localizing signs such as contralateral paresis of the body, unilateral reflex changes or Jacksonian epilepsy are operated on in this clinic, but the results are far from satisfactory. The usual operation is subtemporal decompression. Quite frequently the opening into the skull is not sufficiently large to afford complete removal, but unfortunately, as shown in many autopsy cases, one would have to actually expose the entire one-half or the whole of the brain in order to remove all of the clots, because it is notoriously true that the majority of cases of subdural hæmorrhage are not localized. The outcome in cases who recover is poor, at least so far as my own experience is concerned, the convalescence is long and drawn-out, and quite frequently the patients succumb to intercurrent disease, such as pneumonia.

In conclusion, it can be stated that operations of an emergency nature in cases of skull fracture are those with compound fracture and those with extradural hæmorrhage. The results in these cases are very gratifying. Patients showing progressive focal signs indicative of a localized brain lesion are also considered operable. Careful study of the patient and accurate pre-operative diagnosis are important in the latter group. It is unfortunate that patients are of no help and cannot coöperate in order to complete the clinical studies in a great many cases. Future work possibly may clarify some of these present-day impossible cases. Conservative watchfulness is probably the best slogan to follow in skull fracture work, but one should emphasize the "watchfulness" part of the slogan.

No paper on the treatment of cases of acute brain injury is complete without consideration of methods to check undesirable sequelæ. In case of operative approach the question of visible deformities should be remembered. It is proper to minimize them in so far as this is compatible with careful work. The after-care of cases of brain injury is important. Good habits, moderate mental exertion, restricted fluid intake (Fay) and the occasional use of dehydrating agents are valuable. The régime of restricted fluids is certainly helpful in many cases and future results will undoubtedly tell us more of its merits or short-comings.

In this clinic we do not suggest various symptoms by ardent questioning If they have headache, tinnitus or dizzy spells they invariably tell the examiner about it. A certain number only need the proper suggestion to return at the

next visit complaining of the symptom suggested to them. In this day of various methods of compensation, whether it be from an insurance company, lodge or other societies, subjective post-traumatic sequelæ are common, some undoubtedly genuine and others either manufactured or made worse by various prospects. Psychotherapeutic measures are invaluable. A proper evaluation of the individual's mental state with corresponding psychic therapy and suggestion is helpful. I wonder if the scarcity of subjective post-traumatic sequelæ in children may not be partially explained on the basis that among them the problems of the psyche, proper adjustment and rehabilitation are simpler.

CONCLUSIONS AND SUMMARY.—(1) Seven hundred and eighteen cases of cranial and intracranial injury are reported. In 475 cases the position of the fracture was ascertained by ray, inspection or autopsy. In this group there were twenty-nine frontal sinus fractures, twenty-six foramen magnum fractures, sixty-nine depressions. The most numerous were fractures in the middle third of the skull.

(2) There were 129 cases of bleeding from the ear. The mortality was 31.3 per cent. with right-sided, 30.6 per cent. with left-sided, and 68.9 per cent. with bilateral bleeding. There were two cases of meningitis, three of otitis media, and two of mastoiditis in this group. There were fourteen cases of facial paralysis. Among those with unilateral bleeding eighty-four were rayed with positive fracture finding in 87 per cent. Even though there may be bleeding from a given ear the fracture of the skull may be elsewhere than in the vicinity of that ear.

Bleeding from the nose occurred in 24 per cent. of the cases, vomiting in 21 per cent. and incontinence in 7 per cent.

(3) Convulsions were seen in forty-six cases (6 per cent.). There were twenty-three with Jacksonian attacks, eighteen with epileptiform attacks and five with attacks characteristic of decerebrate rigidity.

(4) Five cases of catatonic states are discussed. The diagnosis of laceration of orbital surface of frontal lobes is considered. Examples of the syndrome of the superior longitudinal sinus and alternating oculomotor paralysis in cases of middle meningeal hæmorrhage are given.

(5) Associated injury in other parts of the body is considered and examples given. There were five cases of meningitis with one recovery. Two cases of aërocele of the frontal sinus, one case of pneumocephalus are discussed.

(6) The values and short-comings of lumbar puncture are considered. It is stated that lumbar puncture should never be done without a careful neurological examination of the patient. Indications for lumbar drainage (always with a manometer) are (*a*) diagnostic purposes in a few cases; (*b*) continued unconsciousness with no focal neurological signs; (*c*) severe post-traumatic headaches and continued drowsiness; (*d*) cases of convulsions with no associated focal signs to justify operative approach; (*e*) cases of meningitis.

Not all cases of head injury deserve lumbar drainage. We should be

guided by the clinical findings. As a rule lumbar punctures are not done in this clinic before six or eight hours have elapsed.

In cases of fractured pelvis, lower extremity bones, where lumbar puncture would be difficult to perform, cysterna puncture may be used with advantage.

(7) Fifty-one operations are discussed. Indications for operation are: (*a*) compound fracture; (*b*) extradural hæmorrhage; (*c*) intradural hæmorrhage with focal signs and not responding to lumbar drainage; (*d*) depressed fractures (slight depressions and depressions in the frontal sinus region are treated conservatively in the absence of findings to justify operation); (*e*) progressive focal signs not responding to lumbar drainage.

(8) Mortality in the entire series irrespective of injuries elsewhere in the body is around 19 per cent. Among those where a fracture of the skull was demonstrated, it is around 25 per cent.

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CHEMICAL TREATMENT OF THE PERIOSTEUM IN THORACOPLASTY TO INHIBIT RIB REGENERATION

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Five years ago, Jerome Head[1] described experiments in which he tested the effectiveness of various chemical agents for preventing osteogenesis after subperiosteal costectomy. He removed pieces of several ribs from each of a number of dogs and then painted the rib-free periosteum with the chemicals before closing the wound. After a lapse of time amply sufficient for bone to regenerate, the animals were sacrificed and the rib beds were examined by X-rays and dissection. Zenker's solution seemed the most suitable of the agents employed, since it prevented osteogenesis completely without producing appreciable necrosis. Meiss[2] reported a similar investigation in 1930. Although he found Zenker's solution quite effective in preventing the formation of new bone, he noted perforation into the pleural cavity in one instance and symptoms (undescribed) of systemic poisoning. He preferred 10 per cent. solution of formalin—an agent not tested by Head—for it had all the advantages of Zenker's solution and none of the disadvantages.

Both authors suggested clinical uses for their methods in certain types of thoracoplasty. Thus, it was recalled that where ribs have to be resected in stages for producing collapse of the chest-wall, "the true collapse occurs only with the removal of the last ribs. Until then the part of the wall of the chest which is already mobilized hangs from the ribs like the curtain of a tent, and, if the bones reform in this position, the final collapse is compromised."[1] Furthermore, the lapse of three weeks between the first and last stages of operation may be sufficient to bring about this undesired result, and yet that or even a much greater interval between the stages is often advantageous or imperative, in order to replenish the patient's strength and morale, to prevent advancement of associated diseases, to permit infected wounds to heal, to test the effectiveness of preceding stages, *etc.* It seemed to Meiss that the method would be useful in paravertebral extrapleural thoracoplasty for pulmonary tuberculosis because it would allow wider intervals between the stages of operation and would permit the chest-wall to continue collapsing slightly for several months after operation, in response to the gradual fibrosis and shrinkage of the lung that occurs with the healing of the disease. He believed that the prevention of rib regeneration would not leave the thoracic wall sufficiently unstable to jeopardize the healing of the pulmonary lesion, for he knew of a patient who had received paravertebral thoracoplasty by *supra*periosteal costectomy and had obtained full benefit to the tuberculous lesion of the lung. Head advised against this application

of the method, on the theoretical grounds of mural instability. Other uses suggested by these authors were as follows: Employment in the graded Estlander operation for chronic empyæma or bronchiectasis, to permit wider spacing of the stages and more prolonged collapse; use in the Brauer cardiolysis, to ensure permanent pliability of the precordium; use in the rib resection for drainage of empyæma or lung abscess, to prevent new bone from forming in, and encroaching upon, the sinus; and use in the rib resection for cautery pneumectomy, to obviate the difficulty which may arise from regeneration of bone in the field of cauterization.

Neither one of the authors has reported clinical experience with his method, and the only reference of the kind that I can find is the bare statement of Trout[3] that he had used the method of Head with satisfaction in thoracoplasty for pulmonary tuberculosis. I began to use Zenker's solution in plastic operations for chronic empyæma soon after the appearance of Head's publication, but changed later to formalin. Twelve cases of that type have been treated with one or the other chemical, and, besides, twenty-three cases with drainage of empyæma, three with drainage of lung abscess, and two with cautery pneumectomy. While this experience is quite insufficient for final evaluation of the methods, the results have been satisfactory and consistent enough to warrant preliminary report.

The first case to be treated was that of a white male, aged thirty-two years. At the time of admission to the hospital, he had been ill for eleven months with productive cough, fever, dyspnœa, and weakness. Five months before the symptoms had become so exaggerated that the patient had to stop work. His physician at the time made the diagnosis of empyæma of the left pleural cavity and established drainage by intercostal catheter. Considerable improvement followed, but soon the cough and fever returned. On admission the patient was found to be emaciated, weak, and toxic. The left half of the chest was markedly retracted and fixed, and it exhibited a narrow sinus at the seventh intercostal space in the posterior axillary line. Tubercle bacilli were abundant in the sputum and in the pus from the sinus. X-ray examination showed an empyæma cavity on the left side with very thick walls, extending from the third rib to the diaphragm and from the anterior axillary line to the vertebral column. An operation was done immediately to widen the sinus. A specimen of the pleura which was obtained at the time revealed the presence of tuberculous infection. The drainage thus established and the supportive treatment that followed produced great improvement of the constitutional condition within two months; but the cavity was unchanged in size, so the decision was made to obliterate it with the graded thoracoplasty of Schede. At the first stage, the lower one-third of the roof of the cavity was removed; but the shock was very severe. So, two months later, when the patient's strength was sufficiently restored, the milder operation of Estlander was resorted to, with the addition that the rib-free portions of periosteum were painted with Zenker's solution. The parts of the ribs lying over the cavity, together with a part of one rib (second) above, were removed in two sittings, with an interval of six weeks between to allow for delayed wound healing. The immediate effect of this was only partial obliteration of the empyæma cavity; but the collapse proved to be progressive and fourteen months after the last operation the cavity was closed, the sinus was healed, and the patient felt well.

In the three other cases of tuberculous empyæma treated since then, the entire lengths of the ribs overlying the cavities were removed subperiosteally

in small and widely spaced steps, with application of one or the other chemical to the periosteum. The cavities collapsed satisfactorily, and only one (see the case report below), which was operated upon very recently, has not yet healed. Graded subperiosteal resection of only the posterior segments of ribs was employed for the patients with extensive non-tuberculous empyæma. This included the ribs over the cavity—and one above if the cavity was subtotal. The result was that the anterolateral segments of ribs, the thickened parietal pleura, and the superficial tissues, which remained over the cavity, fell progressively during and after the operations until obliteration was complete. One of these cases required further work, to unroof a small residual cavity. Thus, in both types of empyæma, the Estlander operation almost entirely replaced the Schede procedure, which hitherto had been indispensable. Since the parietal pleura and intercostal structures were not removed, as in the Schede thoracoplasty, the operations were accompanied by relatively little blood loss and shock and by no paralysis of the abdominal wall. A comparatively small but noteworthy advantage of the chemical treatment was that, after resection of the posterior segments of ribs, the posterior ends of the anterolateral segments developed no spurs.* No appreciable disadvantage was experienced from paradoxical respiratory movements of the chest-wall. Scoliosis developed, but it was no greater—indeed, usually much less—than that after Schede resections for equally extensive cavities. Chemical poisoning was watched for but was not detected. Chronic empyæma cavities, which were so small as to extend under no more than three ribs, were still treated by the Schede thoracoplasty.

The expected benefits were derived, also, in connection with rib resection in the other types of cases. Although the benefits were comparatively slight, they were worth while.

One case was outstanding, because it made possible a direct comparison between Zenker's and formalin solutions as to their effectiveness in preventing osteogenesis.

A Chinese male, aged twenty-three years, was admitted to the hospital with a history of productive cough for two and one-half years. Slight weakness was the only accompanying symptom, until one day three months before when, during unusually strenuous coughing, sudden pain occurred in the right side of the chest and marked dyspnœa developed. He took to bed at once and soon had a chill and started to run a high fever. On admission the man was extremely emaciated and feeble, orthopnœic, cyanotic, and disturbed by a frequent productive cough. The sputum was fetid and contained myriads of tubercle bacilli. Physical and röntgenographical examination of the chest revealed complete collapse of the right lung, fluid and air in the right pleural cavity, extensive displacement of the mediastinum to the left, depression of the right hemidiaphragm, and a light infiltration of the left upper lobe which was suspected to be tuberculous. The chest was tapped. The fluid proved to be thick pus, containing tubercle bacilli, streptococci, staphylococci, and other organisms, and the air was found to be under pressure of plus 3 to 8 centimetres H_2O. The initial treatment consisted

* Hedblom[4] has emphasized the danger of laceration of the pleura and lung that exists during anterolateral costectomy for pulmonary tuberculosis, in removing ribs that carry these sharp, upward curved projections.

in bi-daily aspiration of large quantities of pus and air and in general supportive measures. Within four weeks the dyspnœa was greatly relieved and the mediastinum was returned to the mid-position (Fig. 1); but the secondary infection and fever persisted, so that open drainage was done. At the same operation, ten centimetres of each of ribs 11, 10 and 9 were resected paravertebrally and the rib-free periosteum was painted with Zenker's solution, which constituted the first stage of an Estlander operation to de-rib the entire right half of the chest. The paravertebral wound became infected slightly from its close proximity to the drainage wound. The operation was well borne, nevertheless, so it was decided not to wait for complete healing of the paravertebral incision but to abandon the usual orderly progression of resection and operate the second time at a considerable distance. Consequently, the second stage was performed twenty-six days after the first and consisted in the resection of four to ten centimetres of the posterior extremities of ribs 4 to 1, inclusive, with application of Zenker's solution. The wound healed well. But shortly after this, the temperature became somewhat elevated, the cough increased, and a röntgenogram (Fig. 2) showed

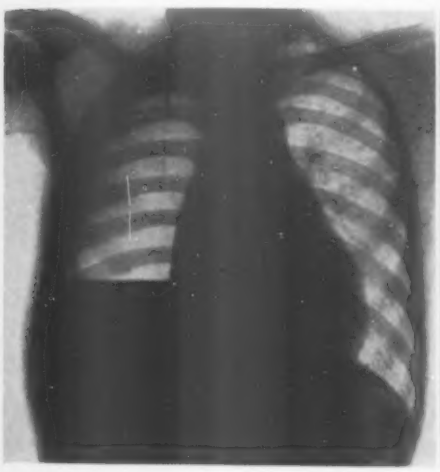

FIG. 1.

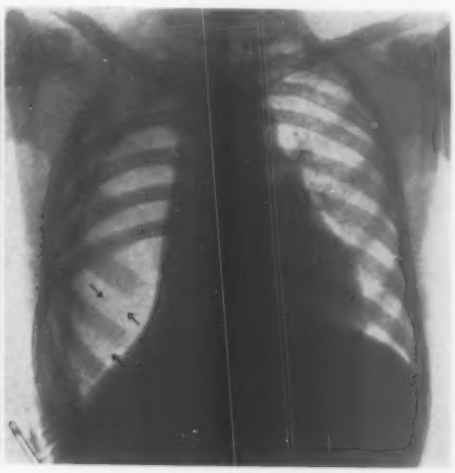

FIG. 2.

FIG. 1.—Thoracic röntgenogram of a case with secondarily infected, tuberculous empyæma and complete collapse of one lung, taken just before the beginning of a graded subperiosteal costectomy wherein Zenker's and formalin solutions were compared for effectiveness in preventing rib regeneration.

FIG. 2.—Same case, thirty-six days after the establishment of open drainage and the resection of the posterior segments of ribs 11 to 9, and ten days after the resection of the posterior segments of ribs 4 to 1. The rib-free periosteum was painted with Zenker's solution. Arrows indicate the foci of new bone from the first operation.

a slight increase in the lesion of the left lung. The same röntgenogram was interesting from the fact that it gave an exceptionally distinct view of the beds of some of the resected ribs—due to the persistence of a bridge of ribs (8 to 5) across the middle of the hemithorax which held the beds widely out—and that it showed definite traces of new bone in the field of the first operation performed thirty-six days previously. The infection in the left lung quieted sufficiently to permit the third stage to be performed fifty-one days after the second, with removal of the anterolateral segments of the upper four ribs; but this time 10 per cent. solution of formalin was used in place of Zenker's solution, according to Meiss' suggestion. The wound healed *per primam*. And once more the condition of the left lung demanded a long wait. A röntgen-film (Fig. 3), taken fifty days after the third stage, showed that the formalin-treated periosteum was free from appreciable amounts of new bone, while the Zenker's treated periosteum of the first operation (127 days before) had developed incomplete but well-defined ribs. The field of the second operation lay too close to the spine to permit clear

discernment of the degree of rib regeneration. The fourth operation came the day after this examination and the fifth came twenty-seven days later, whereby the remaining ribs and portions of ribs were taken out and the periosteum was painted with formalin. Figure 4 gives the appearance ten days after the last operation when the chest-wall was completely collapsed and the merest slit remained of the empyæma cavity. The patient's condition was satisfactory in other respects, also. The cough was absent, the temperature normal, the pulse rate only slightly elevated, and the body weight increased by four kilograms. The lesion of the left lung seemed about the same as at admission. A prolonged period of rest was then indicated, to permit that infection and the one in the collapsed empyæma cavity to heal, but the prognosis was fair.

The results in this case suggest that formalin is much more effective than Zenker's solution. In view of the fact that the collapse of the chest was complete, both in this and in the other cases treated with Zenker's solution, it is very likely that the ribs which regenerated after the use of that agent were

FIG. 3.

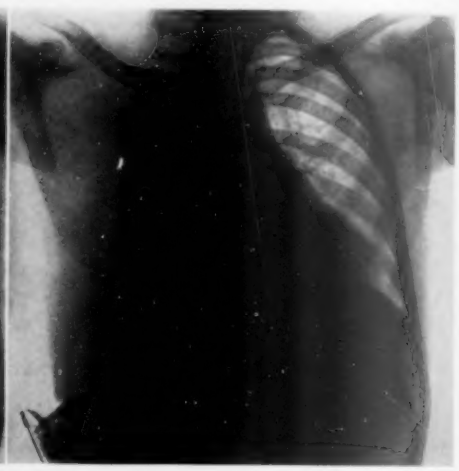

FIG. 4.

FIG. 3.—Same case, fifty days after the resection of the anterolateral segments of ribs 4 to 1 with application of formalin solution (third costectomy). No new bone is visible. Arrows indicate the enlarged, fragmentary deposits of bone 127 days after the first operation.
FIG. 4.—Same case, five months and five days after the first and ten days after the last (fifth) costectomy. Ribs 11 to 1 are absent and the empyæma cavity is totally collapsed.

fragmentary rather than solid. Although formalin seemed to prevent osteogenesis entirely in the instance cited above, proof has since appeared that it permits a slight amount of bone to form. In a case being treated at present by cautery pneumectomy, the slough of the thoracic wall from the first burning contained tiny spicules of bone along the lines of the periosteal beds which had been stripped of ribs and painted with formalin thirty-six days before the burning. The partial regeneration that occurs after both agents probably accounts for the satisfactory degree of stability of the chest-wall that resulted in all of the cases of chronic empyæma. Furthermore, it suggests that the method of periosteal treatment can be applied to paravertebral thoracoplasty for pulmonary tuberculosis without danger of instability of the thorax. This will soon be tested, first with Zenker's solution.

The solutions were applied as follows. After each rib was removed, its

periosteum was sponged free from blood and then wiped throughout with a small gauze swab, which had been dipped in the solution and shaken out. The periosteum was again sponged dry and painted with a fresh swab; and the process was repeated five or six times. This insured that the rib bed received thorough contact with the agent, without much contamination of the surrounding tissues.

SUMMARY.—The discoveries of Head and Meiss are recounted, that bone regeneration after subperiosteal costectomy in dogs can be prevented completely by application to the periosteum of Zenker's or formalin solution, as well as the suggestions of these authors as to possible clinical applications. Personal experience with both agents for this purpose is briefly reported, which concerned forty-three clinical cases, including twelve with chronic empyæma. It is concluded that, in man, both solutions inhibit the reformation of bone markedly but do not prevent it entirely, that formalin is much the more effective, and that the use of one or the other of these chemicals is advantageous in certain operations of rib resection. The chief advantages occur in the treatment of large chronic empyæma cavities, because the Estlander thoracoplasty can be used in place of the more destructive and shock-producing procedure of Schede, the stages of resection can be placed as far apart as desired, spurs do not form on the ribs, the chest-wall continues to collapse long after the last operation.

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LONGITUDINAL BONE GROWTH

THE INFLUENCE OF SYMPATHETIC DEINNERVATION

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Since disturbances of the normal longitudinal growth of bone frequently result in disabling discrepancies in the length of the extremities, they command considerable clinical importance. Especially is this true of the lower extremities in which a disproportion of more than 1½ inches produces a limp, a functional scoliosis and ultimately, in a fair proportion of cases, a painful traumatic arthritis.

To be differentiated from this group are the discrepancies resulting from (1) congenital deformations; (2) loss of bony substance in comminuted fractures and from aseptic and septic necrosis, tumor invasion, *etc.;* and (3) a break in continuity with overlapping of the fragments (traumatic and pathological fractures).

Disturbances in longitudinal bone growth are caused by a large group of conditions which alter the normal physiological process of ossification within the epiphyseal cartilages, and upon this basis may be grouped into five general classes:

(1) Complete or partial destruction of an epiphyseal cartilage may occur in such conditions as bone and joint tuberculosis, osteomyelitis, and new growths.

(2) Premature closure by ossification occasionally results from traumatic epiphyseal separation, damage at operation, and certain obscure growth disturbances such as dyschondroplasia.

(3) Accelerated activity not infrequently obtains in conditions that bring about an increased blood supply to this portion of bone such as adjacent pyogenic and tuberculous bone and joint infections, neighboring neoplasms and arteriovenous aneurisms. Among the more rare and obscure entities may be mentioned dyschondroplasia, giantism, and dyspituitarism.

(4) Irregularities in the rate of growth may occur in portions of the same epiphyseal line producing curvatures of contour (valgus or varus deformities). A discrepancy in the growth of two parallel bones such as the radius and ulna may distort their respective relationships and articular extremities. Examples of these phenomena occur with partial destruction of the epiphyseal cartilage by infection or trauma and in such conditions as multiple cartilaginous exostoses and dyschondroplasia.

(5) Retarded activity is observed as a result of prolonged disuse from any cause. It occurs in chronic bone and joint disease, in certain neuropathical disturbances (notably residual paralysis of anterior poliomyelitis),

in congenital lesions (dyschondroplasia, syphilis) and in certain metabolic disturbances (rickets, cretinism).

In the consideration of treatment of this latter group the possibility of devising a method to bring about an acceleration of bone growth in the short extremity has led to speculation. Clinical and experimental observations in recent years have demonstrated quite conclusively that the interruption of the sympathetic innervation of an extremity removes the function of vasoconstriction and results in at least a temporary vasodilatation. The frequent observation of accelerated growth activity in an epiphysis in close proximity to a chronic inflammatory process (presumably the result of an increased blood supply) led quite naturally to the assumption that sympathetic deinnervation might have a similar effect. This deductive reasoning found application in a case reported by Harris in November, 1930. He states that two years following the interruption of the sympathetic nerve supply of the left leg with a pre-operative shortening of 1½ inches as a result of retarded growth from residual paralysis of anterior poliomyelitis, there was a reduction in this discrepancy of three-quarter inches.

Experimental investigation, however, has failed to corroborate this clinical observation. Cannon and his co-workers have removed the entire sympathetic chain on one side of the body of kittens and infant rats (Bacq) and have observed no increase in growth on the sympathectomized side of the component structures of the extremities, the bilaterally symmetrical soft tissues and viscera with the exception of the reproductive organs. René Simon obtained the same results with rabbits.

These investigators apparently read the results of their experiments only at the conclusion of the growth period, that is, at post-mortem examination. To preclude the possibility of a temporary acceleration of bone growth at some stage in development, the following experiments were carried out. The left lumbar sympathetic ganglia and intervening trunks were removed from four kid goats and semimonthly measurements by X-ray examinations were made of both tibiæ.

EXPERIMENTAL OBSERVATIONS

Experiment I.—Goat 2 (W). Approximate age six weeks; weight 6.0 kilograms. Pre-operative X-rays in lateral views of both lower extremities the right tibia measured 13.6 centimetres, the left tibia 13.6 centimetres.

Operation.—April 27, 1931, morphine and ether anæsthesia. With an exposure through a mid-line abdominal incision the loops of small intestine and the sigmoid were retracted medialward. The posterior parietal peritoneal reflection immediately lateral to the sigmoid was incised and the retroperitoneal space entered. By sweeping the parietal peritoneum medially with blunt dissection, the left lumbar sympathetic trunk and ganglia were exposed. The left lumbar ganglia 2, 3, 4, and 5 and intervening trunks were excised and the defect in the parietal peritoneum closed. By entering the retroperitoneal space lateral to the cæcum the right lumbar chain was exposed but left undisturbed. This was carried out merely as a control procedure.

Surface temperature readings of the lower extremities immediately after operation were: left 32.8° C., and right 30.6° C. By palpation this difference was definitely discernible.

This animal was observed for eight months and both tibiæ were measured by X-ray examination every two weeks during the first four months and at monthly intervals thereafter. The X-ray pictures at the beginning and at the termination of the experiment

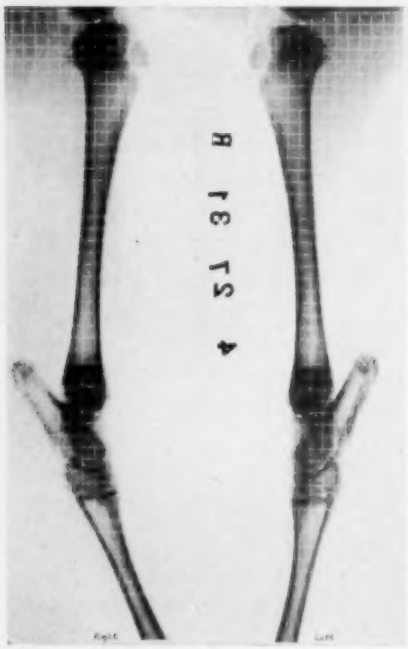

FIG. 1.

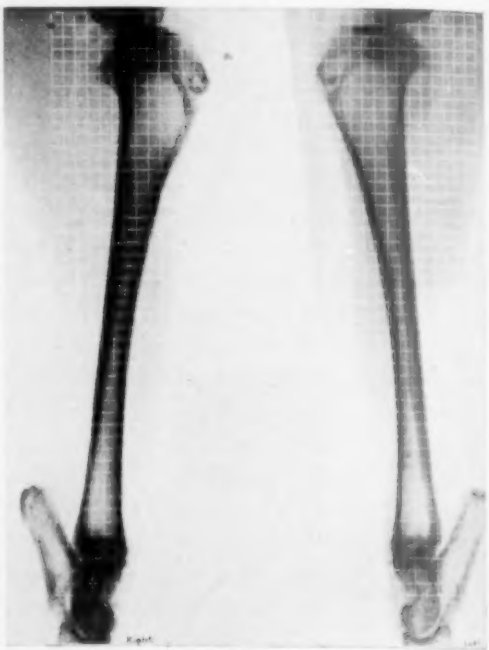

FIG. 2.

FIG. 1.—Röntgenogram of both tibiæ of Goat II on day of operation. Both tibiæ are of equal length, measuring 13.6 centimetres.

FIG. 2.—Tibiæ of same animal represented in Fig. 1, seven and one-half months after a left lumbar sympathetic ganglionectomy. Note that they are of equal length. The longitudinal growth during this period was 6.5 centimetres in each tibia.

are represented in Figs. 1 and 2. In Table I the periodic measurements and body weights are recorded.

TABLE I

Goat 1

Date	Body Weight in Kilograms	Length of Right Tibia (Normal Extremity) in Cms.	Length of Left Tibia (Sympathectomized Extremity) in Cms.
Apr. 27, 1931	6.0	13.6	13.6
May 10, 1931	5.8	14.0	14.0
May 25, 1931	8.5	15.0	14.9
June 10, 1931	11.0	15.8	15.8
June 27, 1931	14.2	16.2	16.2
July 11, 1931	15.5	16.6	16.6
July 26, 1931	18.2	17.2	17.3
Aug. 12, 1931	19.5	18.0	18.0
Sept. 10, 1931	20.0	18.6	18.7
Oct. 8, 1931	21.2	19.0	19.0
Nov. 5, 1931	22.4	19.7	19.7
Dec. 7, 1931	23.0	20.1	20.1

Experiments II, III, and IV.—Goat 3. Approximate age six weeks; weight 5.8 kilograms. *Operation*, April 27, 1931.

Goat 4. Approximate age six weeks; weight 5.0 kilograms. *Operation,* April 29, 1931.

Goat 8. Approximate age six weeks; weight 6.2 kilograms. *Operation,* May 4, 1931.

Precisely the same operative procedures and observations as described in Experiment I were carried out on these three animals and in each instance the interruption of the sympathetic innervation was verified by the higher surface temperature readings (approximately 2° C.) in the sympathectomized extremities. The weights and measurements are recorded in condensed form in Table II.

TABLE II

Date	Body Weight in Kilograms	Length of Right Tibia (Normal Extremity) in Cms.	Length of Left Tibia (Sympathectomized Extremity) in Cms.
Goat 2			
Apr. 27, 1931	5.8	13.3	13.4
July 23, 1931	16.3	17.4	17.4
Dec. 7, 1931	22.6	19.8	19.8
Goat 6			
Apr. 29, 1931	5.0	13.2	13.2
July 23, 1931	14.8	17.2	17.2
Dec. 7, 1931	20.8	20.0	20.0
Goat 8			
May 4, 1931	6.2	13.5	13.5
July 23, 1931	15.0	18.0	18.1
Dec. 7, 1931	24.2	20.2	20.1

To these experiments the objection can be raised that they were conducted upon normal animals and to overcome this objection a parallel experiment to the human cases of shortening resulting from infantile paralysis was sought. From Doctor Hudson, of the Department of Bacteriology of the University of Chicago, a half-grown monkey with open epiphyseal lines and complete symmetrical residual paralysis of both lower extremities with contractures from anterior poliomyelitis was obtained. The infrequent occurrence of this distribution of the paralysis in "polio monkeys" limited the experiment to this one animal.

Experiment V.—Monkey No. 519; weight 1.6 kilograms, operation July 17, 1931. A left lumbar sympathetic ganglionectomy was carried out with the technic described in Experiment I. After operation the left lower extremity was definitely warmer than the right. The subsequent measurements of both tibiæ are recorded in Table III.

TABLE III

Monkey No. 519

Date	Body Weight in Kilograms	Length of Right Tibia (Normal Extremity) in Cms.	Length of Left Tibia (Sympathectomized Extremity) in Cms.
July 17, 1931	1.6	10.2	10.2
Aug. 10, 1931	1.5	10.3	10.3
Sept. 14, 1931	—	10.4	10.4
Oct. 15, 1931	—	10.45	10.45
Nov. 13, 1931	2.0	10.5	10.5
Dec. 12, 1931	—	10.55	10.55
Jan. 14, 1932	2.2	10.6	10.6

The photograph, Fig. 3, was taken with the animal in motion to record the dragging of the paralyzed lower extremities.

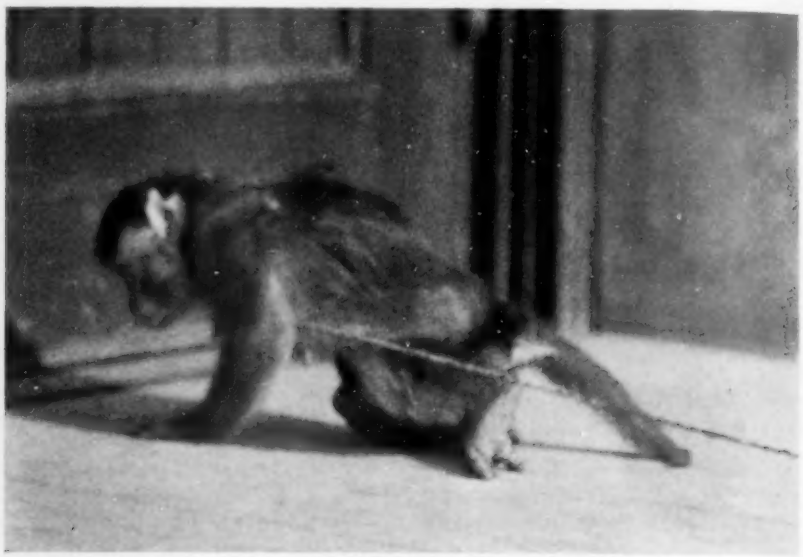

FIG. 3.—Monkey No. 519. Animal in motion. Note dragging of both paralyzed lower extremities.

Figs. 4 and 5 represent the X-ray findings at the beginning and termination of the experiment.

Comment.—The effect of sympathetic deinnervation upon longitudinal bone growth has been studied in four normal kid goats and in one monkey

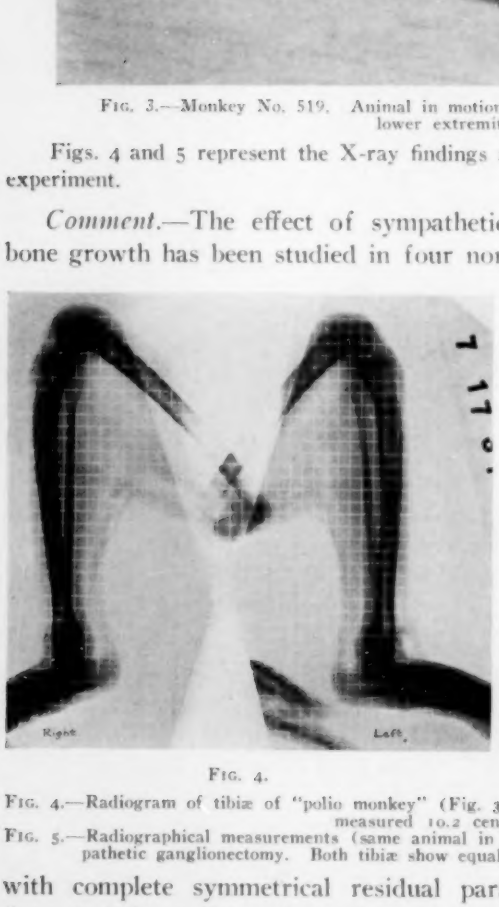

FIG. 4.

FIG. 5.

FIG. 4.—Radiogram of tibiæ of "polio monkey" (Fig. 3) taken on the day of operation. Both tibiæ measured 10.2 centimetres.

FIG. 5.—Radiographical measurements (same animal in Fig. 4) six months after a left lumbar sympathetic ganglionectomy. Both tibiæ show equal longitudinal growth, 0.4 centimetres.

with complete symmetrical residual paralysis of both lower extremities from anterior poliomyelitis. In each instance the left hind leg was deinner-

vated of its sympathetic nerve supply and the right one used for control measurements.

The four goats were observed for eight months and during this period their weights quadrupled and the tibiæ on both sides increased in length approximately 6.5 centimetres. Semi-monthly measurements by X-ray examination, however, have demonstrated that the tibiæ on the sympathectomized sides have at no time evidenced an accelerated rate of growth as compared to the normally innervated extremities.

The "polio monkey" was observed for six months. During this period both tibiæ increased 0.4 centimetres in length and at no time was there evidence of an acceleration of longitudinal bone growth.

From the results of this investigation it is reasonable to conclude that the longitudinal growth of bone was in no way influenced by the removal of its sympathetic nerve supply, either in otherwise normally innervated extremities or in the extremity paralyzed as a result of anterior poliomyelitis. Consequently, there appears to be no experimental evidence to justify the use of this operation in the hope of correcting discrepancies in the length of the extremities by accelerating delayed longitudinal bone growth. The surgical treatment of cases with length asymetry regardless of cause invokes the application of one of three principles: (1) Shortening of the long extremity, (2) lengthening of the short leg, and (3) complete or partial arrestment of growth in the long extremity.

(1) Jacob Von Heine has been credited with the first surgical attempts to correct length disproportions in the lower extremities. In 1840, he reported an operation for the shortening of the long leg. With variations in technical details this operation has been used considerably and the results, although functionally gratifying, have the obvious objectionable feature of shortening the stature of the patient.

(2) In 1905, Codivilla described a method for lengthening the short extremity and reported twenty-two cases with a gain in length varying from three to eight centimetres. This method and its modifications in recent years by Putti, Freiberg, Magnuson, Ombrédanne, Taylor, Fassett, Lambert, Steinman, Hey-Groves, Abbott, Carrel, and others involve the principle of distraction of the fragments of the osteotomized femur or tibia. The main contributions from these modifications have made it possible to control the fragments in alignment and apposition during the period of gradual skeletal distraction. Anatomically, the principle of this operation is ideal but it carries with it the hazards of an extensive operation and the technical difficulties involved in the postoperative lengthening procedure.

(3) Recently, Phemister reported a method for arrestment of longitudinal bone growth by bridging the epiphyseal line with bone grafts. Within a few weeks the epiphyseal line becomes obliterated. With a knowledge of the rate and proportion of growth from the various epiphyseal lines, it is possible by arresting growth in one or more epiphyseal cartilages at the proper time (in respect to age) to retard growth in the long extremity sufficiently to give the short one an opportunity to overcome all or part of the length discrepancy. This operation affords the advantage of a simple nonshocking procedure, but its application is limited to the period of growth.

Conclusions.—(1) In normal experimental animals longitudinal bone growth is not influenced by sympathetic deinnervation.

(2) Retarded bone growth in a monkey with residual paralysis from anterior poliomyelitis was not accelerated by sympathetic deinnervation.

(3) There is no experimental evidence to justify the use of the operation of sympathetic ganglionectomy for the purpose of accelerating bone growth.

(4) The three tried and proved methods of correction of length discrepancies of the extremities are: (1) Shortening of the long extremity by osteotomy, (2) longitudinal growth arrestment of the long extremity and (3) lengthening the short extremity by distraction.

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INTERSCAPULO-THORACIC AMPUTATION FOR SECONDARILY INFECTED TUBERCULOSIS OF SHOULDER

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FROM THE SERVICE OF DR. H. FINKELSTEIN AT THE HOSPITAL FOR JOINT DISEASES

For the most part the indications for interscapulo-thoracic amputations have been extensive injuries or malignant disease about the shoulder-joint. In such cases the performance of this huge operation and the sacrifice of the whole of the upper extremity has been considered of small import in face of the urgent necessity of saving life. In a very small percentage of cases the procedure has been employed in the treatment of large benign tumors about the upper extremity, as in the case of a large chondroma of the humerus reported by Spickers (Journal Med. Soc. of New Jersey, vol. xxii, p. 283, 1925).

Though I have been unable to examine a complete list of all the cases heretofore reported, it appears to have been only relatively seldom used, if at all, in cases of severe infections involving the shoulder-joint.

It is, of course, not my intention to advocate the more extensive use of this tremendous operation in every case of even severe infection about the shoulder-joint. Rather, I hope to direct to the attention of others, as it was called to my attention, that this operation should be at least considered in cases which offer no hope of satisfactory solution by any of the more conservative procedures. In the case herewith presented, no question of malignancy arose and the operation was undertaken solely with the purpose of eradicating an infection which had persisted for several years and which was rapidly leading the patient down hill. It is my belief that in this particular case the operation was life-saving and was amply warranted by the condition of the patient, as well as by its successful outcome.

P. M., male, age thirty-seven, cook; was first seen April 6, 1931, complaining of pain, limitation of motion, and numerous sinuses, from all of which pus issued copiously, completely encircling the right shoulder-joint. The patient first began to have trouble January 18, 1929, when while at work he suffered a severe jerk to his right shoulder, and though he immediately complained of pain, continued at his work. About one week later, because the pain was growing progressively worse, he was seen by his family physician, who could find nothing to account for his symptoms. Twenty-four hours after the onset, however, the condition became so aggravated that the patient, no longer able to continue his labors, was confined to bed. Swelling appeared over the anterior region over the shoulder-joint, there was a marked increase in local heat, the arm became fixed to the side, and attempts at motion of the arm in any direction were extremely painful. The patient was treated conservatively for several months, and finally was admitted to one of the hospitals in the city, where he remained from June to December, 1929. A pre-operative diagnosis of osteomyelitis of the shoulder was made, and "four major operations and numerous incisions and drainage were performed." Pathological material removed during the course of these operations subsequently established the

diagnosis of tuberculosis of the shoulder. In December, 1929, he was discharged from the hospital with multiple sinuses surrounding the shoulder-joint. In February of 1930 he was seen at one of the city hospitals and was thence sent to a city tuberculosis institution, where he remained from March until November, 1930, undergoing conservative treatment. Between the time of his discharge from the last hospital and the time of his first visit to me, he was seen and studied for short periods of time in several other hospitals, at which he was advised against submitting to any further operations.

During this time the patient constantly ran an afternoon temperature and had such severe pain that he never enjoyed a night's rest. Within the four months prior to his examination by me, he had lost about thirty-five pounds in weight.

On admission to the Hospital for Joint Diseases in April, 1931, the patient presented the appearance of a normally developed, markedly undernourished man, not in

FIG. 1.—Infected shoulder tuberculosis requiring interscapulo-thoracic amputation.

severe pain, but obviously chronically ill. His shoulder-joint was surrounded by a number of sinuses of varying size, from which a dirty, yellowish-gray pus was discharging. (Fig. 1.) The arm was atrophic, fixed at the side, and permitted of only a few degrees of passive motion. The spleen was enlarged to about two fingers below the costal margin.

Smears from the wound showed many pus cells. Staphylococcus aureus was grown on culture. The Wassermann test was negative. The blood count showed 3,520,000 red blood cells, 70 per cent. hæmoglobin, 17,500 white blood cells; 63 per cent. neutrophiles, 10 per cent. eosinophiles, 25 per cent. lymphocytes and 2 per cent. mononuclears, with toxic appearance of polymorphonuclears. The stool examination was negative for ova and parasites. The urine showed nothing unusual. The quantitative tuberculin test was strongly positive. The chest was carefully examined by the phthsiologist (Doctor Wiener), who found "no evidence of any active clinical pulmonary tuberculosis. There is a leathery type of friction sound heard in the axillary region on the right side, probably due to old pleurisy. The heart sounds are good and clear. Patient can unquestionably stand a general anæsthetic." X-rays of the right shoulder girdle (Fig. 2)

were reported by Doctor Pomerantz as showing "the shoulder-joint completely obliterated. The margins of the glenoid fossa show irregular erosion. The scapula below the glenoid fossa shows irregular erosion, and cortical bone production. There is some osteoplastic bone production about the coracoid process. The head of the humerus is extremely atrophic and irregularly eroded. Externally, there is a linear calcification probably within the bursa. The neck of the humerus shows active destruction. The cortex and the periosteum at the proximal third show fairly symmetrical thickening. The soft parts about the shoulder-joint show irregular excavations, probably the site of sinuses. *Conclusion.*—Osteomyelitis of the humerus and scapula, with an old pyarthrosis of the shoulder-joint."

In discussing the case with the röntgenologist, I was assured that the presence of a secondary infection would so change the röntgenographic appearance that the typical

FIG. 2.—Skiagraph of infected tuberculous shoulder.

picture of tuberculosis might be completely unrecognizable. However, in the face of a positive pathological report from the hospital where the patient was originally operated on, and positive quantitative tuberculosis tests at our own hospital, I felt that I was justified in considering this as a case of tuberculosis of the shoulder with secondary infection. At first sight, the condition of this patient's right shoulder was so appalling that I was at quite a loss to know exactly what to do. Practically every surgeon who entered within the walls of the hospital was literally dragged in to see this patient and to render an opinion. The opinions received varied in nature from complete conservatism to radical amputation. On first thought, radical amputation appeared to be somewhat too extensive a procedure, and an attempt was made to treat the patient conservatively by immobilizing the arm in a plaster bandage. Subsequently, April 16, 1931, under general anæsthesia an effort was made to gradually abduct the humerus of the shoulder-joint so as to overcome the abduction contracture. In spite of extremely gentle manipu-

lation, the shoulder had been abducted a matter of only fifteen degrees, when a soft yielding rather than a snap was felt, and it was realized that a fracture of the humerus had been produced. This was subsequently confirmed by X-rays. Hesitancy at performing an interscapulo-thoracic amputation was now completely dissipated, and the problem was put squarely before the patient and his family for decision. They were apparently less timid of the outcome and eagerly, indeed joyously, embraced, even at the risk of death, the opportunity of being relieved of an extremity that had been completely useless, as well as a source of constant pain, during a period of two and one-half years.

April 21, preliminary to operation, 600 cubic centimetres of whole blood were transfused by the Unger method, and on the following day a typical interscapulo-thoracic amputation was performed with the kindly and invaluable assistance of Dr. Harold Neuhoff, who had originally advised this procedure.

A four-inch incision was made along the middle of the right clavicle and the clavicle was exposed subperiosteally. A Gigli saw was passed subperiosteally, and the clavicle divided at the junction of its middle and inner thirds. The outer portion of the clavicle was now widely retracted outward, the subclavian vessels and brachial plexus exposed, and the subclavian artery doubly ligated and cut across in its third portion. In attempting to ligate the subclavian vein, a small rent developed proximal to the ligature, necessitating the further resection of about one inch of the inner fragment of the clavicle. The vein was thereupon successfully ligated with No. 3 chromic catgut and divided. The three trunks of the brachial plexus were infiltrated with 95 per cent. alcohol and were divided with perfect hæmostasis. The pectoral muscles were then exposed through a racquet incision, which encircled the axilla, and both major and minor muscles were cut across. With the division of the pectoral muscles, the upper extremity became freely movable. The patient was now turned to the left side and the posterior skin flap raised from the skin incision. The trapezius was divided and the arm pulled forward, making the elevator scapulæ and rhomboid muscles tense. These were divided close to their insertion at the scapula, exposing the serratus magnus and latissimus dorsi, which were similarly cut across. The extremity now remained attached to the body by the omohyoid and the subcutaneous tissues, which were rapidly cut across, after tying their vessels. The cut ends of the muscles were sutured to the chest wall with interrupted plain catgut sutures and the skin was approximated with several interrupted silkworm gut sutures, which allowed drainage throughout the entire wound. Two rubber dam drains were inserted, one emerging from the lower end of the wound and one from the middle of the wound, and a large, dry compression bandage applied. During the entire operation, the patient received about 1,100 cubic centimetres of an intravenous infusion of glucose 5 per cent. in saline, by the continuous drip method. During the whole operation, only a relatively slight amount of blood was lost, because of the excellent hæmastosis afforded by preliminary ligation of the vessels. Although in very mild shock on leaving the operating room, the patient's condition was considered extremely satisfactory, the pulse being 116, and of good quality.

Following operation, the patient made a remarkably uneventful recovery. The post-operative shock was so completely combated, that on the second post-operative day, the patient was anxious to be up and about, but our fears for the integrity of the subclavian ligatures prompted us to keep him in bed. On April 24 transfusion of 500 cubic centimetres of whole blood with the Unger method was carried out, more for the purpose of giving the patient a good start toward convalescence than because of any specific indications. The convalescence was completely uneventful. On the ninth day, the patient was permitted to sit up in bed, and on the eleventh day was walking about the ward. (Fig. 3.) One month later the wound was so far healed that a prosthetic appliance could be fitted to the patient. (Fig. 4.) Shortly after applying this apparatus, however, several small fistulous tracts reappeared along the line of the incision. In spite of their appearance, the patient was discharged seven weeks after operation for ambulant

treatment. These sinuses were lined by white gelatinous appearing, unhealthy granulation tissue, which yielded slowly only to the topical application of caustic silver nitrate.

FIG. 3.—Interscapulo-thoracic amputation.

Since operation, the patient has been able to pursue his normal existence, free from pain and temperature. He has now (February, 1932) returned to somewhat more than his original normal weight, despite the loss of the upper extremity.

FIG. 4.—Prosthetic appliance after interscapulo-thoracic amputation.

The whole upper extremity was sent to the laboratory for examination, and Doctor Jaffe, the pathologist, subsequently reported:

"*Gross.*—Specimen consists of the whole *right* upper extremity, including the scapula. The arm and portion of the shoulder are swollen. There are a number of sinus tracts oozing pus in the arm. On hemi-section of the specimen, large numbers of abscess tracts are found between the muscle groups. There is a transverse fracture at the junction of the upper and middle thirds of the humerus. The narrow cavity of the humerus contains a large amount of hæmorrhagic soft material, which was removed for section. Part of the specimen was macerated and showed a transverse fracture, as described above, with no evidence of healing. There is a slight cortical thickening on one surface, but the other surface shows marked cortical atrophy. The entire humerus shows atrophy. The articular cartilage of the head of the humerus is destroyed. The acromion of the scapula shows an osteomyelitis and the rest of the scapula is extremely atrophic.

"*Microscopical.*—Sections show a very extensive necrotizing inflammatory process, with some of the sections showing a few giant cells and tubercle-like processes. A careful search for tubercle bacilli failed to disclose the presence of any in the tissue sectioned."

Though I realize that the limited experience gained by this case does not entitle me to speak in general terms of this operation, still I feel that in view of the extreme rarity with which this operation is performed, even casual observations may be of some value. In the first place, I feel that both pre-operative, and, if necessary, post-operative transfusions, as well as infusion of glucose saline during the course of the operation, are of the utmost moment in combating the shock of so extensive an operation. This is considered of such value that it is almost of routine nature in all cases of major magnitude treated at our hospital. In performing the operation, some have advised ligating the vessels after the extremity has been almost completely amputated from behind. It is my opinion that preliminary ligation of the vessels is desirable, since it permits of operating in a relatively blood-free field and relieves the operator of considerable anxiety. However, as I review the steps in the operative technic employed on this patient, I have the feeling that a great deal of difficulty might have been avoided had ligation of the artery not been attempted directly at the outset. Early in the operation, despite the severance of the clavicle, the vessels are approached with some difficulty, because of their position in the depths of the wound. If, however, after division of the clavicle, the pectoral muscles be cut across, the whole of the shoulder girdle can be gently pushed back, disclosing the subclavian vessels and the brachial plexus, and rendering their approach for surgical treatment much more felicitous.

RECURRING EXTERNAL DISLOCATIONS OF THE PATELLA *

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The causes of recurring external dislocations of the patella may be divided into three, according to Jones and Lovett: (1) congenital; (2) traumatic; and (3) rachitic. Structural or mechanical would be a more inclusive term for the latter. (1) Congenital cases are those where the patella is small and permanently upwardly, as well as outwardly, displaced. (2) Traumatic cases are those where, following one severe, rather crippling injury accompanied by a rupture of the quadriceps expansion on the inner aspect of the patella and hemarthrosis of the joint, the knee is insecure thereafter, especially on extension against resistance, as in descending stairs, where the patella suddenly slips beyond the confines of the femoral intercondylar notch, the knee gives way, and the patient falls. (3) Structural causes are those wherein the angle of the pull of the quadriceps muscle on the ligamentum patellæ is increased as in knock-knee; infantile or spastic paralysis which causes elongation of the patellar tendon; or in general relaxation of the knee as in genu recurvatum. Goldthwaite originally pointed out that there is an angle formed at the junction of the quadriceps femoris and the patella with the apex inward which tends to become obliterated on contraction of the muscle and is only prohibited from doing so by the prominence of the external femoral condyle and by the strength of the quadriceps expansion mesially, and when these relationships are altered and resistance to this pull lessened the patella dislocates externally.

Of the twelve knees operated upon in this series, six could be considered as traumatic, four as structural and two congenital. Nine patients are represented.

The symptoms and findings of the congenital type are somewhat different from the others. Usually it is noticed shortly after the patient begins to walk that he falls often with collapse of one or both knees, usually both, for the condition is ordinarily bilateral. The patellæ are very rudimentary and upwardly displaced due to a congenital lengthening of the patellar tendon. The tibial tubercle is often laterally displaced, the ligamentum patellæ is entirely without the intercondylar notch, which structure is often not at all developed due to lack of required function, and the patella instead of lying flatwise in the coronal plane of the body is in the sagittal plane. As the patient grows older and heavier and play puts more demand on the functions of the quadriceps, falls become more frequent, so that the patient after awhile depends solely on outside support for locomotion.

In traumatic cases, as before indicated, there is no knock-knee, lack of development of the intercondylar notch or external femoral condyle, or elon-

* Read before the Philadelphia Academy of Surgery, May 2, 1932.

gation of the patellar tendon. Instead there is often palpable a longitudinal rent in the quadriceps expansion to the inner side of the patella. Especially is this true if on first examination there is an effusion in the joint, for in the presence of this the rent or defect is visible as a herniation, or palpable, there being a localized lack of the usual tense resistance felt in a hydrops of the knee. While at rest in extension the patella remains in the intercondylar notch but lateral pressure causes it to slide well out over the external condyle, and, if slowly done, active extension against resistance from a right angle with the part over the edge of a table will cause the patella to partially or completely dislocate externally, usually with some pain. In recent cases of this type there is sharp tenderness on digital pressure over the site of the tear. If treated conservatively in the beginning this defect will heal, but with the stress of use the scar stretches and symptoms come on later with collapse of the part, recurring dislocation and effusion.

In the structural cases, the physical findings are different from the other two types, even though the symptoms may be the same as in the traumatic cases. Knock-knees of varying amounts may be present, there may be atrophy or lack of development of the external femoral condyle. Genu recurvatum or lateral instability of the knee, either paralytic or rachitic, are found often in these cases. With the leg at rest in full extension the patella is partially externally dislocated, riding on the external condyle or even further displaced, and on resisted extension from a right angle the displacement increases without pain as a rule unless there has been a recent severe slipping accompanied by intraarticular damage. This type of case is practically always accompanied by marked arthritic signs with lipping of the joint edge, periarticular crepitation and limitation of motion both in flexion and extension and often a chronic synovitis with effusion. The gait of all patients with recurring external dislocation of the patella is a peculiarly guarded one especially in descending stairs, as in this function lies their greatest disability.

One dislocation of the patella favors another and many times these recurrences occur as often as once a week. With each attack the median patellar ligament, which extends from the patella to the iliotibial band, if not torn primarily, gradually stretches so that it no longer is of value in resisting the angular pull of the quadriceps. When this muscle is not under great tension frequent displacements occur without reaction in the knee, but where the resistance is greater and the tension of the muscle is great the local reactions are more severe and effusions are bound to occur. This probably is aided by the fact that the pain accompanying a partial external dislocation causes a sudden spasm of the hamstrings and immediate acute flexion of the knee with full dislocation of the patella, and with the knee flexed and the patella fully externally dislocated the quadriceps becomes a flexor and so the resultant trauma is decidedly increased.

The condition, when congenital, is apparent, but when acquired need usually be differentiated only from internal derangements of the knee caused

by torn cartilages or loose bodies. The absence of local tenderness over the pathognomonic sore spots in cartilage injuries, the severity of the injury and the ease with which the lateral displacement of the patella can be accomplished with the knee in relaxed extension or in extension against resistance from the flexed position should make the diagnosis easy. The age of onset of this condition is usually in children or young adults, the oldest in this series being thirty-three and the youngest eight years. Females are said to be the more common sufferers and this series bears that out, seven females and two males. Knock-knee, while often a common predisposing factor, was present in but two of the structural cases, the congenital case and in one traumatic case. One traumatic case had definite bow legs.

Elongation of the patellar tendon was present in the congenital case and in one structural case, the boy having spastic hemiplegia from cerebral birth injury.

Patient	Sex	Age at Onset	Age at Operation	Knock-knee	Elongation Tendon
Congenital					
E. M.	F.	Congenital	11	Moderate	Yes
Bilateral					
Traumatic					
J. H.	F.	30	37	None	No
E. V.	F.	33	33	Slight	No
M. C.	F.	19	23	Bow legs	No
C. F.	F.	29	30	None	No
E. L.	M.	13	14	None	No
Bilateral		20	20		
Structural					
A. M.	F.	11	51	Severe	No
Bilateral		12			
E. M.	M.	18	19	None	Yes
M. B.	F.	8	9	Moderate	No

Relative to treatment, Steindler aptly puts it by saying that "conservative treatment is both inadequate and unsatisfactory." If it must be used, muscle exercises to develop the vastus internus, plus either a caliper brace or a knee cage to prevent rotation of the lower leg, might be theoretically of value. A wedge should be worn on the inner side of the shoe both to cause the patient to intoe and to relieve strain on the inner structures of the knee. In spite of these measures recurrences do occur.

Goldthwaite says that of all orthopædic surgical conditions, operation for recurring external dislocation of the patella offers the greatest chance of success.

Many operations of various types have been devised for the surgical cure of this very disabling condition. All have the names of the originators attached but they can be divided into two main types, those on the soft parts alone, and those on the bones or bones and soft parts together. The latter are by far the more satisfactory.

Krogius has devised an operation based on the theory that the inner side of the quadriceps expansion is weak and stretched, thus permitting the patella to externally dislocate. He removes a strip of fascia from the inner side of the patella and inserts it in a longitudinal split in the fascia to the outer side and sews up both sides.

Gallie uses fascia lata in two strips sutured subperiosteally to the patella and fastened under tension to the inner femoral condyle.

Robertson and Whitlock use the tendons of the semitendonosis and gracilis respectively to hold the patella in place by inserting these tendons into the patella or quadriceps tendon.

Like all tendon or fascial transplants elsewhere the structures utilized tend to stretch after a while under the stress of function, and the condition recurs.

The transplantation of the entire tibial tubercle, with its attached patellar tendon, to the inner aspect of the tibia, has been done with success by some writers.

In cases of severe knock-knee a supracondylar osteotomy is necessary to correct the femoral deformity and when this is done the lower fragment with its attached lower leg has been rotated inward up to forty-five degrees to increase the prominence of the external condyle and thus keep the patella in its groove. This is objectionable because of the subsequent severe intoeing that ensues, which can be corrected only by the patient voluntarily walking constantly with the hips in a corresponding amount of external rotation.

Albee devised the operation of a linear osteotomy of the external condyle with the point of the osteotome directed anteriorally toward the patellar notch and the insertion of a tibial bone graft into the defect after prying the external condyle forward, thus permanently making this structure more prominent.

Goldthwaite ingeniously advises the longitudinal splitting of the patellar tendon from the patella to the tibial tubercle, the separation of the outer half and the lacing of this behind the inner half and its insertion subperiosteally on the inner aspect of the tibia. This technic was later modified, in that the portion of the tibial tubercle to which the tendon was attached was removed with the tendon and inserted as above. This procedure insures bony attachment for the outer half of the tendon in its new position.

Patient	Date of Operation	Operations Done	Resulting Function
Congenital			
E. M.	May, 1924	Bilateral osteotomy Goldthwaite-Gallie	Good
Traumatic			
J. H.	Aug., 1928	Goldthwaite and Albee	Full
E. V.	Jan., 1930	Goldthwaite and Albee	Full
M. C.	May, 1930	Goldthwaite and Albee	Full
C. F.	June, 1930	Goldthwaite and Albee	Full
E. L.	Feb., 1927	Repaired rent and Albee	Full
	Feb., 1932	Goldthwaite and Albee	Undetermined
Structural			
A. M.	June, 1927	Bilateral Albee and Goldthwaite	Full
E. M.	Feb., 1931	Goldthwaite and Albee	Full
M. B.	Oct., 1925	Goldthwaite	Poor. Said to have had recurrence. Known to have had condition in opposite knee

While this series is not large, certain deductions have been drawn as to the relative merits of these procedures. In the one case where the Goldthwaite operation alone was done in the presence of moderate knock-knees (M. B.), the result was poor and the patient is said to have had a reoperation.

In the congenital case where a supracondylar osteotomy, a Goldthwaite and a Gallie procedure were all done (E. M.), while there is good function, the patellæ have not remained anteriorally where they were post-operatively.

In the case where the rent in the torn capsule was repaired and plicated and an Albee operation done (E. L.), the patella can be easily manually dislocated laterally, even though function is full and there has been no collapse and falls in the intervening five years.

On the other hand, where the combined Albee and Goldthwaite procedures have been done, as is the case in the remaining eight knees, the patella on all motions of the knee remains in its groove and the function in each case is full. Therefore, this combined procedure is offered as giving the best hope for full function and relief of symptoms.

The incision which has been used is J-shaped wih the long limb up the outer side of the leg and the lower limit of the curved limb extending below the tibial tubercle to the inner side of the knee. The Goldthwaite procedure is next carried out after mobilizing the patellar tendon on each side and the half to be transplanted with its attached tibial tubercle is drawn taut and inserted and attached under the periosteum as far mesially on the tibia as possible.

Next, the Albee procedure is undertaken with a broad osteotome and the external condyle pried forward. The bone graft to be inserted can be obtained from the tibia at the site of the transplanted tubercle, or, better still in our experience, from the side of the femur just behind the osteotomy cut, and it is then forcibly inserted into the prepared space.

The wound is closed in layers with interrupted sutures and a small rubber tissue drain is inserted at the osteotomy level, to be removed in forty-eight hours. A molded gypsum splint is applied to the whole length of the leg and the patient is kept in bed for two weeks.

When the sutures are removed a walking plaster bandage is applied from the groin to above the malleoli, kept from sliding down by adhesive strips attached to the leg, the lower ends turned up and incorporated in the plaster of Paris. The patient is permitted to walk in this for four or five weeks and then it is removed. No forcible motion is permitted and rarely is physiotherapy necessary, except, perhaps, massage to the quadriceps. Within six months from operation full motion returns to all and in some a much shorter interval is necessary.

There were no operative deaths or infections but the development of a hematoma at the osteotomy site proved annoying in a few early cases following which the rubber tissue drain was added to the technic.

In conclusion, from this small series one might stress a few apparent facts:

(1) Structural defects were present in but 50 per cent. of the twelve knees.

(2) No operations on soft tissue alone held the patella in its groove.

(3) The combined Goldthwaite and Albee operation has proven most satisfactory.

(4) Surgical treatment offers a safe and reliable cure for a most troublesome disability.

CASE REPORTS

Congenital.—E. M., female, aged eleven years. Noticed by parents that knees collapsed shortly after learning to walk. Patient's father, deceased, had the same complaint. As she got older she became unable to walk without help either by crutches or another person. On examination the patellæ were about one-third normal size and permanently displaced upward and to the outer side of the leg with the side of the patella in the sagittal plane of the body. There was moderate bilateral knock-knee. Operation May, 1924, two weeks separating the procedures on either leg, consisted of the Goldthwaite, supracondylar osteotomy and the Gallie fascial grafts. For five years she intoed very much but gradually actively overcame the deformity. No collapse of knees until 1931, when she married, became pregnant and gained much weight, when, unless she was careful, her knees would feel as though they would collapse and for the last two months of pregnancy she was kept off her feet to prevent this. After delivery she was rapidly brought back to normal weight and her knees now do not collapse. The patellæ have increased in size to about 60 per cent. normal. Her legs are straight, she has 20 degrees of extension right, and 25 degrees of extension left, actively against gravity measured from a right angle. She lives an active and comfortable life as a housewife, but the patellæ have gradually been drawn further laterally.

Traumatic.—J. H., female, aged thirty-seven years. Trouble began seven years before operation with a fall when she struck her knee against a curb. Following this the weakness progressed with frequent accompanying falls. Operation August 28, 1928. Goldthwaite and Albee combined procedures with the repair of a rent found in the inner side of the quadriceps expansion. There was no knock-knee. By January 18, 1929, had sixty degrees active and passive motion from full extension. She then tripped and fell and broke the opposite ankle, upon recovery from which the affected knee was fully restored to normal with the patella remaining in its groove.

E. V., female, aged thirty-three years. Slipped while walking about an elevated platform one week before admission. Slight knock-knee and marked effusion with the patella presenting on the lateral aspect of the knee. This had recurred twice within the week. Operation January 15, 1930, combined Albee and Goldthwaite procedures. June 20, 1930, had full, active extension and flexion to ninety degrees, gait normal, comfortable with the patella pointing forward and remaining in its groove.

M. C., female, aged twenty-three years. Four years before admission while playing tennis her knee gave way and patella became laterally dislocated, since which it had recurred often on use. There had been a chronic effusion for a year which was aggravated on injury. Definite bow legs. Operation May 4, 1930, combined Goldthwaite and Albee operations. There was full function on August 19, 1930, with the patella remaining in the groove and with the power of extension as strong as in the opposite leg.

C. F., female, aged thirty years. Three months before admission while playing on the floor with her children with her knees flexed, the affected knee gave way and the patella slipped laterally with marked subsequent effusion. Since then, whenever she flexed her knee the dislocation would recur, whether bearing weight actively or in flexing the knee passively. There was no knock-knee. Operation June 4, 1930, Albee and Goldthwaite combined procedures. December 1, 1930, there were no complaints, function was full and the patella could not be displaced from its notch.

E. L., male, aged fourteen years, right knee; aged twenty years, left knee. No knock-knee. In July, 1926, while standing erect, was deliberately pushed in the right popliteal space by another boy and his knee gave way. He was immediately unable to use the part and there followed a severe effusion. There were many recurrences before admission. Operation February 1, 1927. A longitudinal rent five centimetres long of the inner capsule was plicated, after excising a rolled-up edge 0.7 centimetre in diameter

and three centimetres long which had become cartilaginous. The Albee operation alone was then done. There was full motion June 22, 1927. This knee has not collapsed, but the patient says it feels weak at times, and although on use the patella remains in its notch, when the part is relaxed in extension the patella can be easily displaced laterally without pain. While descending stairs in February, 1932, he was pushed by another person and his left knee gave way. He was again unable to walk. A severe hemarthrosis followed which was aspirated (200 cubic centimetres) and an elastic support applied, and on attempting to walk the knee gave way again accompanied by a second hemarthrosis, less severe. The patella was easily manually dislocated laterally. Operation February, 1932, combined Goldthwaite and Albee operation. Walking plaster bandage recently removed and patella cannot be manually displaced. Motion of thirty degrees from straight and no discomfort. End-result not fully determined.

Structural.—A. M., female, aged fifty-one years. Symptoms began at age of twelve years, one side by a fall and the other in attempt to kick a football. Severe knock-knees with five inches between the malleoli with the condyles together. In the intervening period each knee would give way without warning ten or twelve times a year, usually in descending stairs. Has worn elastic knee caps and braces without complete relief. Lately before admission was house fast because of fear of falls. On admission each patella was riding on or outside the external condyle. Against gravity from right-angle flexion only thirty degrees active extension was possible in either knee. Passively there was full extension on the left, and the right, which had more recently given way, lacked fifteen degrees of full passive extension. Passive flexion was possible only ninety degrees accompanied by severe intra-articular grating and all signs of localized traumatic arthritis with effusion. Operation right, June 13, 1927, and left, June 3, 1927, combined Albee and Goldthwaite operations. September 1, 1927, had full function with active motion each knee against gravity of ninety degrees to and from full extension. There has been no subsequent collapse or symptoms although the patellæ may be said to present themselves riding the external condyle although still in the groove. In June, 1928, the right internal semilunar cartilage was removed for internal derangement of her knee without disturbing the result from the previous operation.

E. M., male, aged nineteen years. Suffering from left spastic hemiplegia. One year before had fallen from some steps, injuring left knee. Knee clicked and grated on motion and patella was habitually externally dislocated. The patella was high and the tendon long. The legs were straight. Operation February 26, 1931, combined Goldthwaite and Albee operation. Full motion and function in July, 1931. The patella remained in the groove at all times but there was slight pain in the knee on descending stairs.

M. B., female, aged nine years. Fell April, 1925, while roller skating, since which left knee gives way often, especially when running or roller skating. Painful at first, not so lately. Knock-knee, two inches between malleoli with condyles together, and on extension of the lower leg against gravity or resistance patella dislocated laterally. Operation October 28, 1925, Goldthwaite only. In September, 1926, full motion knee and no symptoms referable to operated knee, but opposite patella, without injury, was becoming habitually dislocated. While never seen again it is reported that since then the patient's right knee has been operated upon and the left one re-operated upon because of a tendency to recurrence of external dislocation of the patella.

THE TREATMENT OF MAL-UNION FOLLOWING UNREDUCED POTTS' FRACTURE

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of New York, N. Y.

FROM THE THIRD SURGICAL DIVISION OF THE HOSPITAL FOR RUPTURED AND CRIPPLED

Potts' fracture is a fracture of the lower end of the fibula with a serious injury to the lower tibial articulation, usually a chipping off of the internal malleolus or rupture of the internal lateral ligament, associated with a lateral dislocation of the foot and ankle. When this type of fracture is improperly reduced or treated, serious deformity and changes in the ankle-joint and considerable disability follow. This end-result picture is a rare occurrence but in clinics like these at the Hospital for Ruptured and Crippled, we see several cases a year and, of course, only in adults. The patients complain of incessant pain on walking and are dependent on apparatus or crutches to take the weight from the affected member. Arthritic changes of traumatic origin soon appear and the ankle is considerably swollen, tender and the motions are restricted or lost. Pain is often present at the knee-joint due to the valgus position of the ankle and the faulty weight-bearing surfaces, thus indirectly throwing the strain on the internal lateral ligaments of the knee.

Correct alignment of all joint fractures should always be eagerly sought for and one should have no hesitancy in proceeding with open reduction in all fractures about the joints, if proper position cannot be secured by closed methods. Even in the cases of joint fractures, when perfect alignment is secured (Figs. 1 and 2), there is a tendency in a certain number of cases for arthritic symptoms to appear from five to twenty years later.

The type of open operative treatment for cases of mal-union following unreduced Potts' fracture is one I have developed in our hospital with the idea of correcting the vertical and transverse alignment of the angle-joint proper, which tends to throw the weight-bearing in its proper normal line. It has proven satisfactory as to appearance, relieving the pain and the return of motion to the ankle-joint.

Operative technic.—The leg is prepared in the usual manner and the operation is best performed with a tourniquet. The skin and subcutaneous tissues about the internal malleolus are divided and the lower end of the tibia exposed as shown in Fig. 7—A, A'. A similar incision is made over the external malleolus (B, B') but it is not necessary to expose the lower end of the fibula. The old fracture line in the deformed internal malleolus is removed with a chisel, taking out a wedge of bone (Fig. 9—E). A linear osteotomy of the lower end of the fibula is performed and the foot is placed in marked inversion, until the vertical and transverse alignment of the ankle-

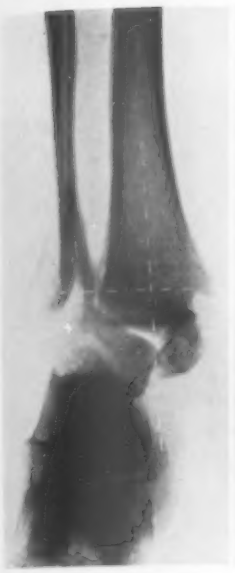

FIG. 1.

FIG. 2.

FIG. 1.—Shows typical fresh Potts' fracture.
FIG. 2.—Shows fracture (Fig. 1) five years after reduction. There are beginning arthritic changes, which may occur in best anatomical replacement. The alignment is perfect.

FIG. 3.

FIG. 4.

FIG. 3.—Photograph of legs, showing typical deformity of unreduced Potts' fracture (left) *i.e.*, swelling of ankle, valgus deformity and prominence of internal malleolus.
FIG. 4.—Same as Fig. 3 one year after operative correction of deformity. Legs are symmetrical.

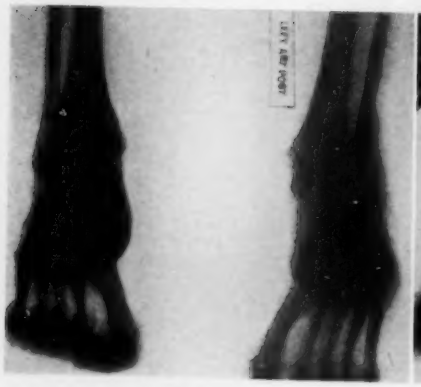

FIG. 5.

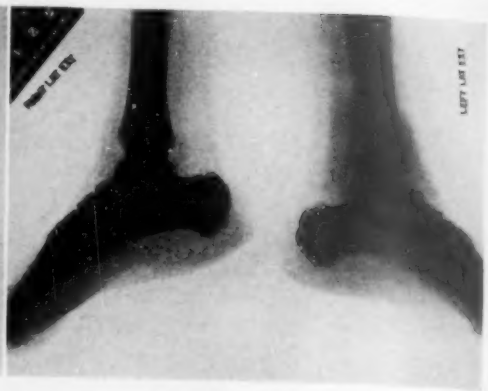

FIG. 6.

FIG. 5.—X-rays of normal ankle as compared to deformity of unreduced Potts' fracture. Note the alignment of weight-bearing, which is distorted on affected side. (X-ray is of case shown in Fig. 3.)

FIG. 6.—Lateral view of Fig. 5. Note distorted internal malleolus.

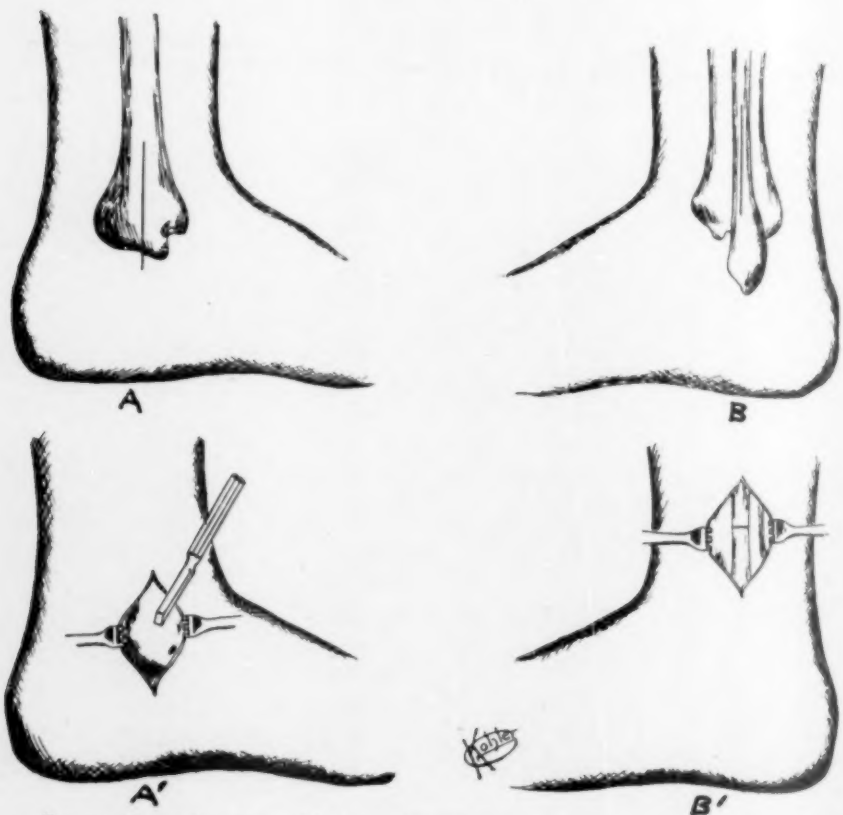

FIG. 7.—Shows the skin incision over internal (A and A') and external (B and B') malleoli needed for operative treatment of unreduced Potts' fracture.

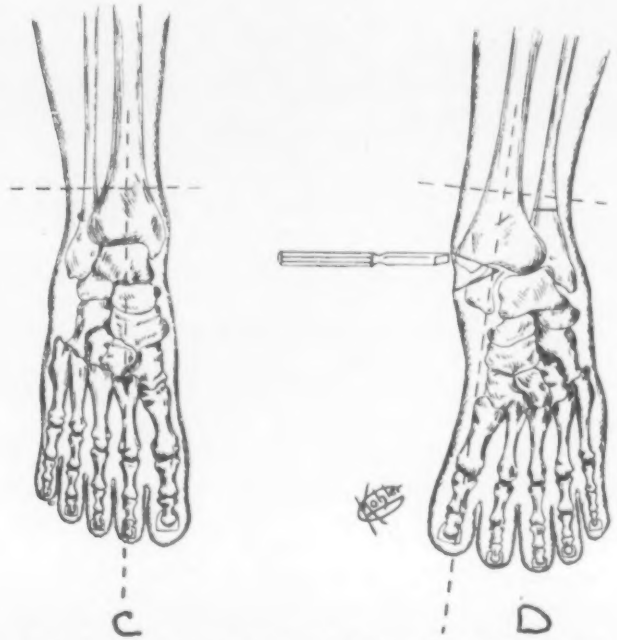

FIG. 8.—Shows drawing of normal ankle (C), with its normal weight-bearing line, and deformed ankle (D). A chisel is in place for cutting wedge to be removed from internal malleolus.

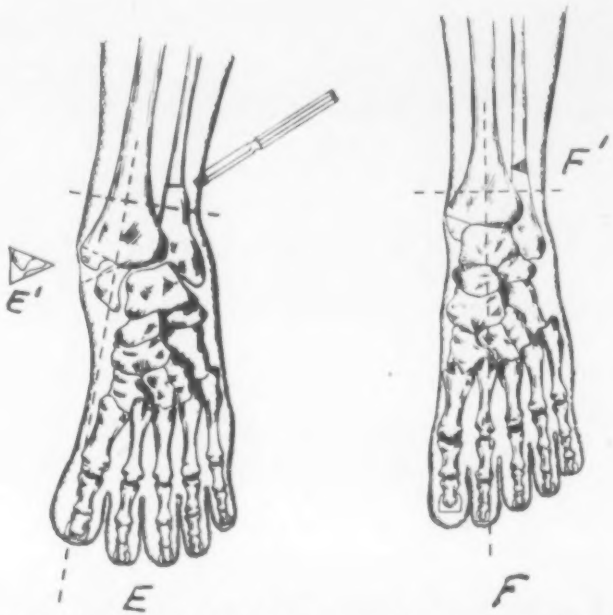

FIG. 9.—Shows wedge (E') of bone removed from internal malleolus and chisel in place to divide fibula. F shows deformity corrected and normal weight-bearing line restored. The vertical and transverse alignment of ankle-joint has been restored. The wedge (E') has been inserted at F' and holds foot in corrected attitude.

FIG. 10.

FIG. 11.

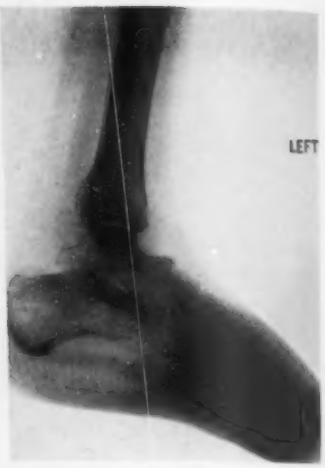

FIG. 12.

FIG. 10.—Shows post-operative result of Fig. 5. Foot placed in plaster in attitude of marked inversion.

FIG. 11.—Shows post-operative result one year after weight-bearing has been permitted.

FIG. 12.—Lateral view of Fig. 11.

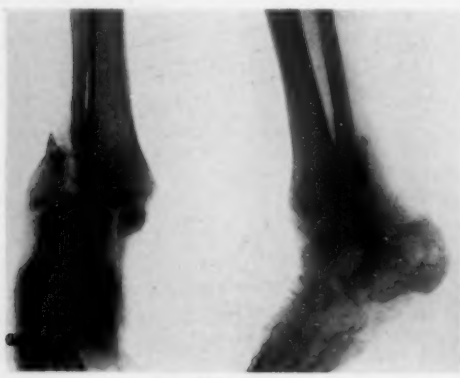

FIG. 13

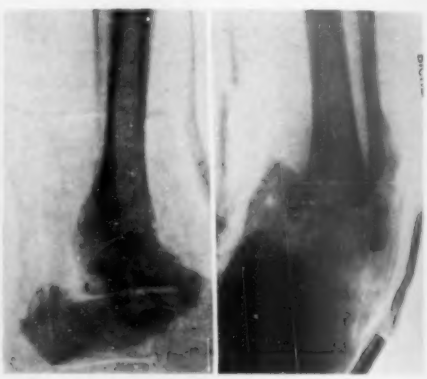

FIG. 14.

FIG. 13.—Shows X-rays of case one year following fracture. (Extreme deformity.)

FIG. 14.—Shows X-rays of Fig. 13 after operative correction. Foot in marked inversion.

FIG. 15.

FIG. 16.

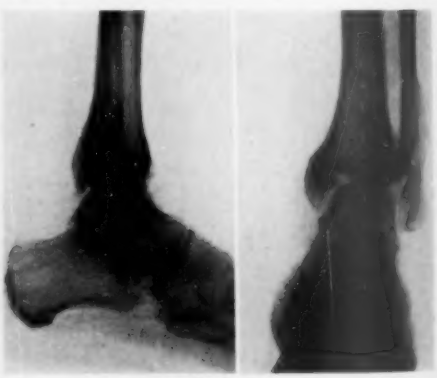

FIG. 16A.

FIG. 15.—Shows X-rays of Fig. 13 one year after operative correction.

FIG. 16.—Lateral view of Fig. 15.

FIG. 16A.—Shows X-rays of Fig. 13 two and one-half years after operative correction, with proper weight-bearing line still retained after continuous weight-bearing. No arthritic changes. Symptom free.

FIG. 17.—Shows X-rays of comminuted fracture of tibia and fibula with same deformity as Potts' fracture.

FIG. 18.

FIG. 19.

FIG. 18.—Shows operative correction of Fig. 17. Wedge removed from tibia shown placed between ends of divided fibula. Vertical and transverse alignment of ankle-joint made normal. Foot in marked inversion.

FIG. 19.—Lateral view of Fig. 17.

joint is secured as shown in Fig. 9—F. The wedge of bone (Fig. 9 E) is reshaped and placed between the separated ends of the fibula (Fig. 9 F) and should hold the foot in its newly assumed corrected attitude. A plaster dressing is applied with the foot in marked inversion. The plaster should extend from the toes to the knee.

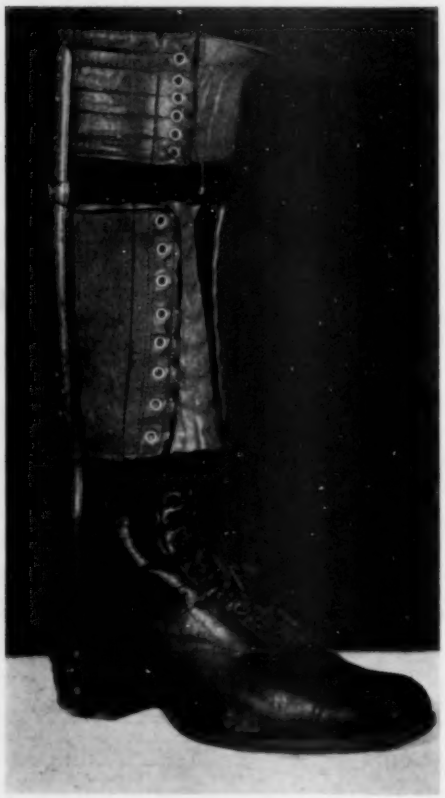

FIG. 20.—Caliper brace inserted in heel of high shoe.

After treatment.—At the end of six weeks from the date of operation a plaster is reapplied with the foot in slight inversion and the patient is encouraged to bear weight. Ten weeks from the operation a caliper brace (Fig. 20) to fit in the shoe and extend to the knee is applied. The function of the brace is to prevent a recurrence of the deformity by restricting any lateral motion and to allow flexion and extension of the ankle-joint. Walking is encouraged in the corrected attitude and physiotherapy is not particularly indicated. All support can be usually discarded about seven months after operation, when all signs of traumatic arthritis of the ankle-joint have disappeared.

SUMMARY.—Fourteen cases have been corrected by this method with pleasing results. The limp is the last symptom to disappear and usually in the second year. I have had one complete failure because the brace was not used following the removal of plaster, which I now consider as important as the operative technic.

SUBCUTANEOUS ANGIOMAS OF THE BREAST

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and Joseph Colt Bloodgood, M.D.
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From the Pathological Laboratory of the Department of Surgery of Johns Hopkins Hospital and University

Of approximately 3,000 breast cases collected in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, the total group of angiomas includes eight benign and one malignant cases. Of the eight benign cases, seven proved to be hemangiomas and one lymphangioma. Only one of the seven hemangiomas was made up of the capillary variety; the six remaining cases belong to the cavernous type. The malignant angioma proved to be a malignant hemangio-endothelioma.

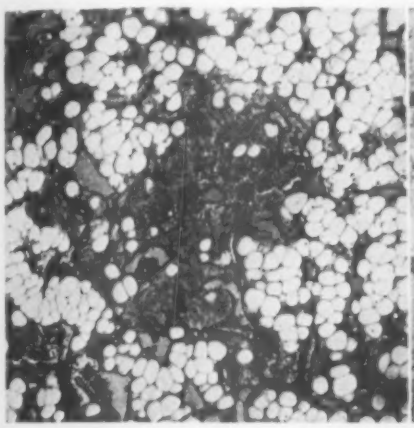

Fig. 1.

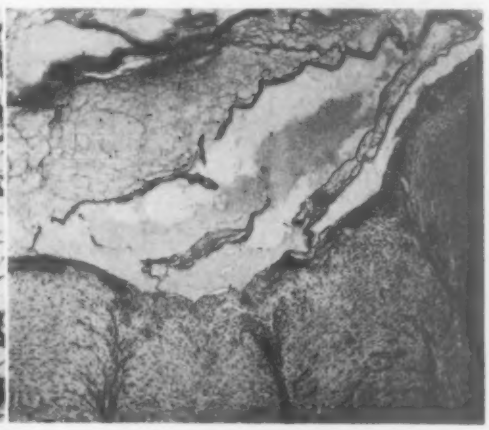

Fig. 2.

Fig. 1.—P. N., 36958, a white female, sixty-two years of age, who, five months previously, accidentally discovered a painless mass in her left breast, which had steadily increased in size. The left breast was slightly larger than the right. There was a suggested retraction of the nipple. In the upper, outer quadrant of the left breast there was a hard, irregular elastic mass, nine by five centimetres, which was attached to the overlying skin. Two pea-sized glands were felt in the left axilla. A diagnosis of sarcoma was made and a radical amputation of the left breast was performed. Two years later a symptomless mass appeared in the right breast together with tumefaction in the right axilla. *Operation.*—An excision of both masses was performed. *Result.*—The patient was well three years later. *Diagnosis.*—The breast tissue from both operations proved to be that of benign capillary hemangioma of the breast. Note.—The tissue photographed was taken from the second operation.

Fig. 2.—P. N., 16380, a colored male, six weeks of age, who presented a congenital, ovoid, colorless, cystic mass in his left breast. *Operation.*—The mass was excised. *Result.*—The result is not known. The microscopical picture reveals a section of a dilated and cystic lymph space. The contents, consisting of a fine, pink-staining mesh-work, is typical of coagulated lymph. The lining of the cavity is composed of partially desquamated and faintly visible, flattened, endothelial cells. The wall consists of fibrous tissue and is only faintly distinguished from the surrounding fibrous stroma. The stroma presents a slight round-cell infiltration. *Diagnosis.*—Lymphangioma (benign) of breast.

The term angioma implies a growth of newly formed blood- and lymph-vessels and includes the two classes: hemangioma and lymphangioma. For practical purposes both are subdivided into capillary (telangiectatic) and cavernous, although any gradation between these two extremes may occur. These lesions occur so infrequently in the breast that a more complete classification is insignificant.

Capillary (telangiectatic) hemangiomas are considered by Ribbert[1] to

arise from isolated segments of a vessel wall and to extend by a proliferation of new vessels. Ewing[2] believes that the logical explanation lies in a developmental anomaly found in vascular segments, which have retained their embryonal elements. Mallory[3] believes that many of them are congenital and that the growth rate is rapid.

The cavernous hemangioma may be attributed to a weakening of the muscular and elastic coats lining the vessels. Rindfleisch and Borst[4] stress the retraction of the fibrocellular growth in and around the vessel wall causing a shortening of the vessel and a dilatation of its lumen.

A certain percentage of the angiomas appear in the epidermis, but in the present study, they are classed as skin lesions and are not considered as angiomas of the breast. Subcutaneous lesions having no connection with the epidermis are the only tumors considered in this paper.

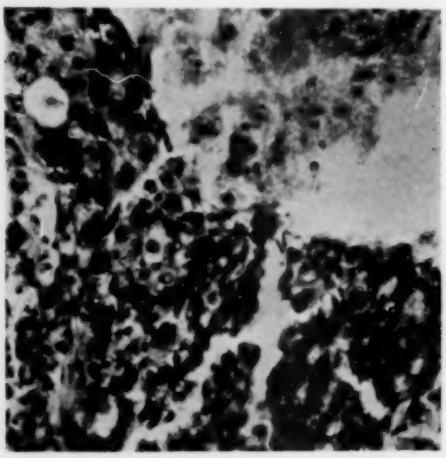

FIG. 3.—P. N., 18844, a female, fifty-three years of age, who complained of a slowly enlarging tumor in her breast. Examination revealed a cystic tumor in the lower-outer quadrant of her breast and a slight enlargement of the axillary glands on the corresponding side. *Operation.*—A radical amputation of the breast was performed February 2, 1916. *Result.*—The patient died in 1926. The microphotograph represents a section of a cyst-wall and a small portion of the cyst lumen. The multiplicity and variation in the size of the hyperchromatic nuclei loosely situated in their cytoplasmic bed indicate a high type of malignancy. However, in spite of this malignant appearance, the patient lived ten years post-operatively. The nuclei are more characteristic of malignant endothelial cells than of any other type. A part of the cystic lumen is shown filled with red blood-cells and an occasional desquamated endothelial cell. *Diagnosis.*—Hemangio-endothelioma (malignant) of the breast.

From a clinical standpoint the recognition of angiomas has been difficult. This is particularly true in regards to the diagnosis of malignancy and benignancy. In the present series two (Path. No. 43645 and Path. No. 36958) of the seven benign hemangiomas were diagnosed clinically as being malignant. Path. No. 36958 (Fig. 1) represents a capillary hemangioma which grew slowly for one and a half years and from the presenting signs and symptoms was diagnosed as a sarcoma. The corresponding breast in this case was subjected to a radical amputation. Path. No. 43645 represents a cavernous hemangioma which was diagnosed clinically as a malignant growth and the breast amputated as a result. (See Figs. 1 and 2.)

The one lymphangioma (Path. No. 16380, Fig. 2) in the present series, occurred as a congenital growth in a colored male child. This mass was removed when the child was only six weeks of age.

The malignant hemangio-endothelioma is represented by Path. No. 18844. (Fig. 3.) This tumor was diagnosed clinically as a malignant growth but both the clinical and microscopical opinions varied from sarcoma to medullary carcinoma. However, the microscopical picture being more typical of malignant hemangio-endothelioma than any other type of breast pathology, the tumor was classed as a malignant angioma.

A correct estimate of the age incidence and duration of growth is impossible in this series. Although the majority of the tumors are found in middle-aged and old individuals the young and very young were almost equally represented.

A small number of cases and the incomplete data on them necessitate the incorporation of typical angiomas in general, in so far as they fit in with the cases studied, in order to furnish a complete and thorough description of angiomas of the breast. However, specific illustrations and outstanding points of the present series of breast angiomas will be stressed.

TABLE I

Subcutaneous Angiomas of the Breast

Path. No. 43745.—Female, aged thirty-one years. Operation.—July 30, 1928, excision of nodule. Result.—Lost. Microscopical Examination.—Cavernous cyst, endothelial lining, blood contents.

Path. No. 43645.—Colored female, aged twenty-one years; malignant tumor in right breast. Operation.—July 12, 1928, amputation of breast. Result.—Lost. Microscopical Examination.—Cavernous cyst, endothelial lining, blood contents.

Path. No. 40926.—Female, aged sixty-four years; benign adenoma tumor of right breast and right lower quadrant of twenty-four years' duration. Operation.—October 4, 1928, excision of tumor. Result.—Lost. Microscopical Examination.—Cavernous cysts, invaginated and endothelial lining, blood contents.

Path. No. 40312.—Female. Operation.—March, 1928, excision of tumor. Result.—November 12, 1929, well. Microscopical Examination.—Cavernous cyst, invaginated endothelial tissue and calcification.

Path. No. 38778.—Female. Microscopical Examination. Cavernous cyst, organization by fibrous (fibro-adenoma associated); blood contents.

Path. No. 36958.—White female, aged sixty-two years; malignant sarcoma of upper, outer quadrant of one and one-half years' duration. Symptoms.—Gradual growth tumor. Operation.—July 25, 1925, radical amputation of breast. Result.—Lost. Microscopical Examination.—Multiple capillary spaces, endothelial lining, blood contents.

Path. No. 36958.—White female, aged thirty-five years; gradual growth tumor of two years' duration. Operation.—July 24, 1922, excision of tumor. Result.—Lost. Microscopical Examination.—Cavernous cyst, endothelial lining, blood contents.

Path. No. 18844.*—Female, aged fifty-three years; malignant cyst(?) of lower outer quadrant. Symptoms.—Slow growth tumor; slight enlargement of axillary glands. Operation.—February 2, 1916, radical amputation of breast. Result.—Dead, 1926? Microscopical Examination.—Cavernous cysts, malignant endothelial lining, blood contents.

Path. No. 16380.†—Colored male, aged six weeks; benign cyst in left breast of six weeks' duration. Symptoms.—Congenital, ovoid, cystic tumor. Operation.—October 1, 1914, excision of tumor. Result.—Lost. Microscopical Examination.—Cavernous cyst, endothelial lining, coagulated lymph contents.

* Indicates a malignant-hemangio-endothelioma.

† Indicates a lymphangioma.

Hemangioma.—The simple, capillary (telangiectatic) hemangioma is represented by hypertrophy and hyperplasia of the endothelium of capillaries and veins which has probably arisen from the stimulation of an embryonic rest lying in the wall of a vessel. The cavernous type in all probability represents a regressive phase resulting from the loss of tone and structure of the vessel wall. The weakness of the vessel walls may be the result of

a congenital defect. The dilatation is characterized by a thinning of the vessel wall and a decrease in the intercellular stroma. Growth takes place by the budding of new vessels in the periphery of the lesions and usually begins as a simple or capillary form before merging into a cavernous variety.

Clinical Features.—Clinically, unless angiomas are sufficiently close to the skin to give a discoloration and an irregular, fluctuating, compressible mass, the diagnosis is difficult. There is no characteristic age distribution nor is there any sex limitation. In spite of the fact that the average age in the present series is 37.7 years, the tumors usually appear at an earlier age and progress very slowly. Cavernous angiomas are as a rule single but, as Esmarch[5] has already shown, they may be multiple. The tumor may be circumscribed, and, in the regressive form, is encapsulated. Of angiomas in general it may be said that the association of these tumors with an afferent and efferent vessel may lead to a fluctuation in the size of the tumor. This phenomenon is sometimes noted during the periods of gestation and menstruation. In cases where angiomas anastomose with large arteries and veins it is possible for a rupture to produce fatal hæmorrhage. Hemangiomas may undergo regressive change together with ultimate fibrosis and calcification, Path. No. 40312. (Fig. 4.) This change may occur spontaneously or may follow irradiation treatment The three most dreaded complications are rupture, infection, and malignant change.

The great majority of hemangiomas are benign, but in some cases malignancy does occur. For this reason one should always regard a hemangioma with suspicion until proved benign. A case of mestastasizing cellular hemangioma of the breast has been reported by Borrmann[6] in which the tumor recurred repeatedly after operation and finally proved fatal by metastasis to the lungs. Onsy,[7] in a report of rare pathological tumors, demonstrated an angiosarcoma of the breast. Ewing[2] observed an angioma of the left breast with metastasis to the lungs. Schmidt[8] reported on eleven cases of angiosarcoma in 1887.

The hemangio-endothelioma of the present series, Path. No. 18844 (Fig. 3), occurred in a fifty-three-year-old woman who presented a slowly growing cystic tumor accompanied by axillary gland enlargement. After a radical amputation of the breast the patient lived for approximately ten years. In spite of the enlarged glands no microscopical sections or any other clinical evidence of metastasis was found in the laboratory.

Gross Pathology.—The capillary (telangiectatic) variety exhibits a soft mass composed of small dilated capillaries and venules which, on section, are found to contain blood. The fibrous septa are prominent and offer a good stromal support for the vessels. The cavernous type presents a larger, more circumscribed growth composed of distended cyst-like structures which are interrelated and which are connected with an afferent and an efferent vessel. Section reveals a spongy mass composed of blood-filled sinuses separated by thin connective-tissue septa. A break in the lining or a weakening of the septa will produce very large dilatations.

Occasionally the presence of organization is found in the contents of the angiomas and if it has been present for a long time deposition of calcium salts may also be noted. (Fig. 4.)

The gross specimen of the malignant hemangioma, Path. No. 18844 (Fig. 3A and B) presented a bloody mass of necrotic tissue which was unidentified as any typical pathological growth.

Microscopical Pathology.—The presence of numerous small blood-vessels lined with endothelial nuclei and usually filled with blood is the typical

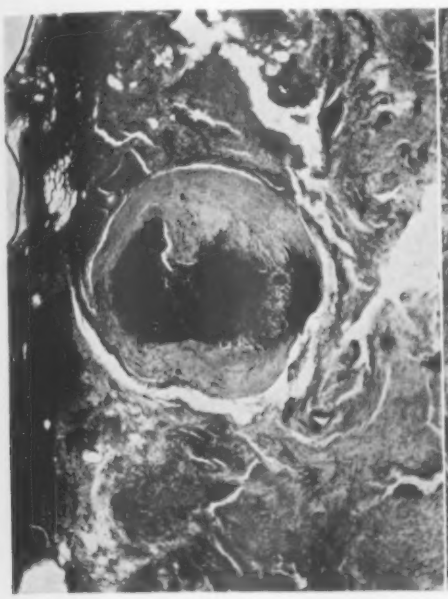

FIG. 4.

FIG. 5.

FIG. 4.—P. N., 40312, a female who complained of a mass in her breast. *Operation.*—The mass was excised. *Result.*—The patient was well one year and eight months later. The microscopical picture shows the end-result of an organized cavity in a case of cavernous hemangioma. Remains of the endothelial lining may be seen. The contents of the former cavity are representd by the proliferation of a collagenous fibrous tissue surrounding epithelial débris. Deposition of calcium salts may be seen within the collagenous fibres as well as within its fibrous wall. The surrounding stroma contains compressed cavernous spaces, which are partly undergoing organization, and an abundance of round-cell infiltration. *Diagnosis.*—Hemangioma, cavernous (benign), of the breast.

FIG. 5.—P. N., 40926, a female, sixty-four years of age, who complained of a symptomless "lump" in her right breast. Examination revealed a painless, lobulated, elastic, fluctuating mass, two and a half by three centimetres, which gave the impression of a group of cysts. However, the tumor was diagnosed clinically as an adenoma. *Operation.*—Under novocaine analgesia the mass was excised. *Result.*—The result is not known. The microscopical picture shows multiple dilated cavernous spaces filled with blood and lined with flattened endothelial nuclei which are, in places, reduplicated. Several cavernous spaces show evidence of epithelial lined, invaginated, fibrous stalks which in one instance have almost bisected the cavity. The fibrous stroma shows evidence of a benign round-cell infiltration. *Diagnosis.*—Hemangioma, cavernous (benign), of the breast.

picture of capillary (telangiectatic) hemangioma, Path. No. 36958. (Fig. 1.) The lining is usually intact and the nuclei, which are seldom reduplicated, take on a dark chromatic appearance. The surrounding stroma, which is usually well developed, may or may not possess a lymphocytic infiltration. These tumors most frequently invade fat and fibrous tissue. When not connected with the general circulation the angiomas form concentric vascular whorls which frequently thrombose. The thrombi are followed by organization with fibrosis and calcification.

The cavernous type, Path. No. 40926 (Fig. 5) presents a varied appearance. The dilated blood spaces are lined with more elongated endothelial nuclei than those seen in the capillary form. These nuclei have a tendency to duplicate themselves. The lining is seldom regular. It is either broken through and leads to another blood space or the lining is invaginated by fibrous stalks which often bisect the blood caverns. The cavernous type is usually filled with blood. The stroma is sparse, being composed of loose, fibrous connective tissue with occasional nerves and blood-vessels. Near the periphery of the lesion there is sometimes found a budding of new vessels which simulate the capillary (telangiectatic) hemangiomas. They represent the growing portion of the tumor, and, unless regression takes place they will in time dilate into the cavernous form. Encapsulation of these vascular spaces is seen in the latter part of the disease when organization and retraction take place. Occlusion of the lumen, often produced by injury to the vessel wall, prevents the circulating blood from passing through the angiomatous beds and as a result these beds have a tendency to form a concentric mass. Invasion by fibroblasts with the deposition of collagen is frequently noted and when organization begins it usually continues to the ultimate stage of calcium deposition. Angiomas are occasionally complicated by infection and hæmorrhage, but rarely by malignant change.

The microscopical section of the malignant angioma in this series shows typical multi-layered, hyperchromatic, endothelial nuclei lining blood-filled cavities. The nuclei contain an abundance of mitotic figures. (Fig. 3B.) It may be argued that this tumor developed from a hæmorrhagic medullary carcinoma. Such a view is not supported by the multitude of medullary carcinomas in the laboratory.

Lymphangioma.—These tumors arise from lymph vessels and may be the result of a blockage of the afferent lymph vessels producing a stasis and a damming in the lacteals and lymph channels with ultimately the production of dilatation and tumefaction. However, they may also be the result of a congenital weakness in the vessel wall and may grow from the stimulation of embryonic rests. The only case collected in this series occurred as a congenital lesion in a Negro boy. (Fig. 2.) Clinically, these tumors present a picture similar to hemangiomas. Regardless of their proximity to the skin, the tumors are colorless. With the exception of complications, which are rare, the growths are symptomless and are noted only when tumefaction has proceeded to the point of detection. With few exceptions these growths are found subcutaneously and, in time, produce a tumefaction which is visible externally. Lymphangiomas of large dimensions have been described by Wegner[9] and Pinner.[10]

Grossly, these tumors, which are comprised mainly of the cavernous type, present a grayish-white, translucent, lobulated, cystic mass, which, on section, often shows a spongy tissue containing grayish-white (lymph) fluid.

Microscopical Pathology.—The cavernous type of lymphangioma is seen in the great majority of cases. Rarely does one see the simple or capillary

(lacteal) form. The cavernous type, Path. No. 16380 (Fig. 2) is characterized by cystic dilatations filled, for the most part, with coagulated lymph and occasionally with the addition of red blood-corpuscles. The lining varies slightly from an oval to a flattened endothelial cell, which is sometimes reduplicated. The lining is very delicate and is occasionally invaginated into the lumen by a connective-tissue stalk. The stroma is composed of fibrous connective tissue which varies in density and which frequently contains a lymphocytic infiltration in its bed. This infiltration is greater than the corresponding type frequently found in hemangiomas.

The occurrence of both lymphangioma and hemangioma in a single tumor is not infrequently seen.

Discussion.—The angiomas of the breast present an interesting though infrequent group of breast tumor. They are at times difficult to diagnose clinically and when once diagnosed they may be even more difficult to treat. The lesions are usually found in middle-aged individuals as slowly growing, semi-fluctuating, subcutaneous tumors. Although the present series shows malignancy in 11 per cent. of the cases, many lesions are incorrectly diagnosed as such, Path. No. 43645 and Path. No. 36958, and unnecessary mutilating operations performed. However, since malignancy does occur this possibility should always be considered. Hemangiomas are particularly dangerous, not only in regards to malignant change, but also because of the constant possibility of fatal hæmorrhage.

A correct diagnosis of angiomas is essential, for the treatment depends on this clinical verdict. The presence of a circumscribed, irregular, spongy and cystic mass arising in the subcutaneous tissues of the breast, especially having a history of long duration, should always arouse the suspicion of angioma. However, an opinion should not be formulated until the procedure of a complete history, inspection and palpation has been carried out. The aid of transillumination (Cutler[11]) as in all breast lesions should be used. However, its use has to be accepted with reservations, for no work has been done on the differentiation between angiomas and chronic cystic mastitis. The cases in the present study were seen before the work of Cutler was published.

Blue-domed cysts, especially when occurring as a part of so-called chronic cystic mastitis, may frequently be mistaken for angiomas.* When transilluminated the cysts are clear and should be less opaque than the blood-filled angiomas. The above statement is based upon the fact that in general, blood-

* Blue-domed cysts transilluminate clear. Hemangioma transilluminates dark. Lymphangioma clear. Neither as clear as the blue-domed cyst or as dark as the hemangioma. At exploration the blue-domed cyst is even a more definite gross pathological picture than the encapsulated adenoma. The blue dome is exposed as the operator uses the knife slowly and moves it from side to side as he proceeds beneath the subcutaneous fat, or after passing through breast tissue, or beneath the breast itself. When the cyst is nicked, the blue color disappears, the contents are clear or cloudy, never bloody; the wall is smooth.

filled cysts can be distinguished from clear-fluid cysts for in the former an opaque shadow is cast while in the latter the cyst transilluminates clear. The presence of large cystic masses casting a dark shadow on transillumination should be treated with suspicion, for such cases are difficult to diagnose clinically. Although the majority of malignant hemangiomas of the breast reported in the literature showed evidence of metastasis, the case in the present series (Fig. 3A and B) lived for ten years after operation with no available evidence of metastasis.

Because shadows are cast by the transillumination of hemangiomas, intracystic papilloma, and chronic cystic mastitis, the diagnosis in these conditions should be guided principally by the clinical picture. In contrast to the angiomas already described, chronic cystic mastitis usually presents a diffuse shotty breast. In some cases, and especially in the presence of papillomatous cysts, the picture is characterized by clearly outlined, definite, hard nodules which have a history of shorter duration and which occur deeper in the subcutaneous tissues of the breast. Another important clinical feature is the one popularized by Bloodgood,[12] *i.e.*, the history of a disappearing tumor in chronic cystic mastitis. Finney[13] believes that the outstanding points of difference between angiomas of the breast and chronic cystic mastitis are the rarity of the spongy, cystic angiomas as compared to the frequent occurrence of chronic cystic mastitis with its firm and localized nodules.

Treatment.—The treatment of angiomas in the past has been extremely varied. The scientific advancements following in the wake of surgery have been slowly progressive and have to date culminated in a more satisfactory form of treatment.

In 1833, Macilwain[14] reported successful results following the injection of pieces of thread. This was followed by the introduction of chemical substances and Giraldes,[15] in 1854, working with perchloride of iron, was probably the first to report successful results. The chemicals used by the early authors include iodine, phenol and potassium iodide. Recently, interest in chemical therapy has been revived, to a certain extent, by the popularization of salicylates, sugars, quinine, and urethane, *etc.*, in the treatment of varicose veins. Heat and pressure were also popular methods of collapsing and sealing the walls of angiomatous areas. Wyeth,[16] in 1902, introduced the method of injecting boiling water into the tumor areas. Because of the pain, discomfort and general poor results suffered from the above methods they have gradually fallen into disuse.

Good results have been reported with the use of electrolysis and carbon dioxide, but they are inferior to those produced by irradition.

The susceptibility of angiomas to radium therapy and the good results obtained by its use have justified its recommendation as a most conservative though efficient form of therapy. MacKee[17] advises soft beta rays in all lesions which are not deeper than two to three centimetres, but prefers radium to X-ray in the treatment of cavernous angiomas. In his treatment

he advocates flat applicators screened with 1/10 to 1 millimetre of aluminum with a dose just a little less than the amount required for a first-degree reaction. The treatment may be repeated every three or four weeks depending on the size and depth of the lesion. Although MacKee prefers beta rays in treating lymphangiomas, he has not obtained very good results in the treatment of these tumors. Among the recent reports of radium therapy on angiomas are those of Coliez[18] and Simpson.[19]

The small, localized angioma may be safely excised but the possibility of cutting down on a vascular, infiltrating tumor is always present. On the other hand, the larger and more diffuse lesion, which is usually a cavernous hemangioma, should never, by choice, be excised, for this tumor is usually very vascular and, because of its growth, perfect hemostasis is, at times, impossible. Although Light[20] has reported successful treatment of a cavernous hemangioma by the injection method and that injections should be used only in certain types, the author believes that the effects of radium therapy justify its recommendation. However, if excision is insisted upon, irradiation should be used pre-operatively, for the shrinkage it produces lessens the possibility of hæmorrhage.

In cases where the diagnosis of angioma is strongly suspected, irradiation should be used, but with the knowledge that poor or slow results should be followed by more radical treatment. In such conditions exploration with biopsy and frozen section diagnosis should always be resorted to.

CONCLUSIONS

(1) Angiomas of the breast are rare. A total of nine cases were found in a collection of approximately 3,000 breast tumors.

(2) There are two types of angiomas in the breast, namely: hemangioma and lymphangioma. The angiomas are subdivided into the capillary and cavernous types.

(3) The exact etiology is unknown.

(4) There is no characteristic age incidence.

(5) The lesions may be congenital. Their symptoms are usually of long duration.

(6) Angiomas may occur in the male as well as the female breast.

(7) Malignancy occurs in 11 per cent. of the cases and is of the hemangio-endothelial variety. The one case in the present study showed no metastasis and lived ten years post-operatively.

(8) A correct diagnosis is essential.

(9) Irradiation with certain reservations should be the first treatment instituted.

SUPPLEMENTARY NOTES BY DOCTOR JOSEPH C. BLOODGOOD

Doctor Menville has asked me to write a note on this study of a rare type of benign breast tumor. Doctor Menville is the first to collect the hem- and lymph-angiomas of the breast among the cases recorded in the laboratory and presents for the first time in American literature a thorough and comprehensive study of the actual

relative positions of these angiomas among a large group of breast cases which have been collected in one surgical clinic since 1892.

The importance of such studies of benign conditions of the breast is greater today than ever before. In the days when Velpeau wrote his book on the breast (1840), the diagnosis could be made clinically and confirmed by the gross pathology and the result, which in Velpeau's time was always fatal in malignant tumors. Now and then, as recorded by Billroth of Vienna, a so-called serocystic sarcoma of Brodie would live for many years after the complete removal of the breast and tumor. Very few students of breast lesions realize that Velpeau wrote his book before the microscope and in his introduction to the second and third editions calls attention to the errors of the microscope in diagnosing malignancy of breast lesions. We now know that it was not the fault of the microscope, but the early microscopic pathologists could not compete with Velpeau's clinical and gross pathological experience. William H. Welch, in a conversation with me some years ago, found the same to be a fact when he travelled through our great Western cities. The surgeons were very much like Velpeau, men of large clinical and gross pathological experience. Their pathologists were still young and inexperienced, and when Welch was called upon to settle differences of opinion, he usually found the microscopic pathologist in error.

When Halsted came to Johns Hopkins in 1889 he ranked highest among the gross pathologists in the world. The records of the Surgical Pathological Laboratory of his department of surgery prove this. On but a very few occasions did Halsted diagnose benignancy in a breast lesion from the naked eye appearance which later, on microscopic appearance proved to be malignant, and this diagnosis of malignancy was confirmed by the subsequent death of the patient from cancer. I remember distinctly the first case. It was a smooth-walled cyst containing blood; cancer could not be seen in the wall of the cyst; yet, later, the microscope showed it. Halsted first removed the cyst only; after the microscopic study he performed the complete operation; the highest axillary glands were involved. The patient died of cancer.

We learned for the first time then that smooth-walled cysts filled with blood are malignant. Nevertheless it would be wise always to make a frozen section of the wall. I could imagine an organized hematoma to appear as a smooth-walled blood cyst, and some of the cases reported by Doctor Menville are described as cysts containing blood. For this reason a benign hemangioma may have the gross pathology of a blood cyst. It has been my misfortune not to have seen one so far. If the cyst contains a papilloma, the hemorrhagic contents is no longer diagnostic of malignancy. I have recently, in the American Journal of Cancer (vol. xvi, pp. 103-176, January 1932), and ten years ago in the Archives of Surgery (November, 1921, vol. iii, pp. 445-542; Reprint 99) reported on border-line breast tumors which have accumulated, from all sources, in the laboratory during all these years. Most of the early cases were explored by Doctor Halsted himself. He examined them most critically with the naked eye and removed locally. They were all examples of non-encapsulated adenoma, or zones of chronic cystic mastitis. Ultimately they were diagnosed microscopically as adenocarcinoma, malignant adenoma, or suspicious of malignancy, and usually within a few days or two weeks the complete operation for cancer was performed. A larger number of cases of this type were received from outside sources. Practically all of these patients have been followed for five or more years after operation. Many are living today. In not a single instance did signs of malignancy develop before death, usually of other causes, or among those living today. Doctor Halsted's acuteness in the recognition of malignant breast tumors by the naked-eye appearance is most dramatically shown in these observations. It is important to remember that during Doctor Halsted's activities up to 1915 the great majority of breast tumors were malignant and, with few exceptions, recognized as such clinically, all of them very distinctly in the gross.

Since 1915 we have required a frozen section with increasing frequency to differentiate the benign from the malignant.

This is due to the fact that perhaps the most common pathological condition occurring in the female breast is chronic cystic mastitis. This bilateral disease of the breast may be present without any clinical evidence. The clinical evidence—pain, tenderness, discharge from one or both nipples, single or multiple lumps in one or both breasts—may be present a month or two and then disappear forever or to return in a certain per cent. of the cases. For this reason the longer a woman waits after observing anything unusual in one or both breasts, the less the likelihood of finding chronic cystic mastitis. In the first ten years of Halsted's clinic, up to 1900, 80 per cent. of the women who entered the clinic because of some trouble in the breast were found to have cancer, and among the 20 per cent. with benign lesions only a small number belonged to the type of chronic cystic mastitis.

In that decade, which ended thirty years ago, in less than 1 per cent. of the women whose records we still have were not operated on, because clinically the condition was benign and the surgeon for some reason postponed operation during which time the palpable tumor disappeared.

Coincident with the education of women in regard to the danger of delay when anything unusual is observed in one or both breasts, there has been a tremendous change in the relative frequency of benign and of malignant tumors of the type of the benign tumor, and a great increase in the number of benign conditions for which, surgeons are learning, operation is not indicated nor necessary. The largest number of cases in this latter group are chronic cystic mastitis.

We need more studies similar to this one of Doctor Menville's of the rarer benign lesions of the breast and especially of their microscopic appearances. It is essential that there should be a follow-up, and the most valuable cases are those in which more than five years have passed since the operation and the result is known irrespective of the extent of the operation. In the list of cases reported by Doctor Menville the unfortunate thing is that in the majority of cases the patient has been lost track of. It is to be noted, however, that in the Surgical Pathological Laboratory of the Johns Hopkins Hospital a large number of these rare tumors, on account of their rarity, and the difficulty of an accurate diagnosis, are received from outside sources and for this reason are more difficult to follow for many years. There is, however, a distinct hem- and lymph-angioma of the breast. It may or may not give the compressibility of a hemangioma; it may or may not have the distinct gross appearance of an angioma; it may or may not appear as a blood cyst. Therefore it must be recognized at the exploratory incision by the aid of a microscopic section. Malignant hemangioendothelioma, or the malignant lymph- or hemangioma have a microscopic appearance very difficult to differentiate from the benign. We have just had such an observation in which the tumor first appeared on the forearm. The certainty that the lesion was malignant was not established until there was local recurrence which temporarily disappeared under irradiation and then recurred again after a second local removal followed by amputation and then death from metastasis.

Doctor Menville has placed before us everything it was possible for him to get from the records and the pathological study of the material. The failure of the follow-up was not his fault.

I am writing this discussion, because I wish to present at every opportunity the necessity for clinicians, operators and pathologists to familiarize themselves with chronic cystic mastitis. To repeat, it is the most common condition of the breast among women who are examined in a few weeks after the first symptoms, among women whose breasts are examined in the routine physical survey and who have observed nothing unusual about the breasts. My personal studies and those of my associates in the laboratory lead to the conclusion that chronic cystic mastitis is not a lesion that precedes cancer. The presence of this bilateral lesion of the breast, whether found

clinically or at the operation, does not justify the removal of the breast. In a large per cent. of the cases it can be recognized clinically, in all it should be discovered at the exploratory incision. The microscopic appearance of chronic cystic mastitis is more puzzling to the pathologist than the clinical signs.

This disease known most commonly under the term chronic cystic mastitis is observed in women during the cancer age—after twenty-five years. It may appear clinically as a single lump, or as a lump in each breast, or multiple lumps in one or both breasts. The lumpy breast in which as a rule the lumps are indistinct is with the rarest exceptions bilateral. This is true also of the shotty breast known as the breast of the Schimmelbusch or Réclus type. Then there is a clinical and pathological type which I have described as more common in women at the menopause or shortly after lactation. One feels beneath both nipples one or more masses which feel like a single worm or a bunch of worms. I have described this as the varicocele tumor of the breast. The most common clinical type of chronic cystic mastitis is a single tumor which when explored proves to be a blue-domed cyst, when opened has clear or cloudy fluid. Dr. Robert Abbe of St. Luke's Hospital in New York, aspirated these cysts before 1900. Today I have returned to this method. The most helpful diagnostic sign is found on transillumination of the breast as first practiced and advocated by Dr. Max Cutler. If the palpable tumor is larger than a twenty-five cent piece and transilluminates clear, whether it is single or multiple, operation is not necessary. If the tumor does not disappear or becomes larger, or annoys the patient by fear or pain, aspirate it. If the fluid is clear or cloudy, do not operate. It is important to note that when the fluid is any other than clear or cloudy, the transillumination will be dark. When a single tumor, smaller than a twenty-five cent piece transilluminates clear we have not yet had sufficient experience to postpone exploration, but we have learned that when a doubtful tumor is explored and a blue-domed cyst is exposed, it is no longer necessary to excise that cyst with a zone of breast. All one needs to do is to open the cyst, let out the fluid, inspect and palpate the surface of the cyst and take a small piece of the wall and the surrounding breast for frozen section. The advantages of this minor operation over complete excision of the cyst with a zone of breast tissue, are that the wound in the breast is insignificant, no plastic closure of the breast is necessary, and the patient may, with the least risk, leave the hospital the same day.

I propose to ask Doctor Menville to make a second report on lymph- and hemangioma of the breast in which he will take up the differential clinical diagnosis and, if possible, ascertain the results in some of the cases recorded as lost.

That this angioma of the breast is rare is exhibited by the fact that I have never explored one. The operators in the nine cases recorded here were either some other surgeon associated with the Johns Hopkins Surgical Clinic or the specimen was received from outside sources.

JOSEPH COLT BLOODGOOD.

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THE EFFECT OF BLOOD IN EXPERIMENTAL PERITONITIS*

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Duff Allen,[1] in 1927, showed that the presence of blood in the pleural cavity was an important factor in the production of experimental empyæma. The addition of one to two cubic centimetres of autogenous blood to broth cultures of pneumococci and streptococci injected into the pleural cavity of dogs gave a much higher incidence of empyæma in these animals than in those receiving similar cultures without blood. From his experiments, Allen concluded that blood increased the incidence of empyæma and believed that under such conditions an increase in virulence of bacteria might be the result.

The peritoneum of animals is well known to be resistant to infection, especially by artificial means. In attempting to evaluate various means of treatment in the experimental animal, the problem of developing a satisfactory peritonitis became one of primary importance. The introduction of organisms into the peritoneal cavity of rabbits and guinea-pigs has failed to produce peritonitis consistently.

The belief that blood may have a deleterious effect by reason of its being a good culture media existed many years before Allen's publication. Thus Schumann,[12] in 1921, in his monograph on ectopic pregnancy, discusses this feature of blood in the peritoneal cavity. The usual result of blood in the peritoneal cavity in ruptured ectopic pregnancy when the hæmorrhage is not so rapid as to cause death or immediate surgical attention, seems to be the formation of an hematocele.

This Schumann explains on the basis that blood acts as a foreign body, setting up peritoneal irritation and aseptic peritonitis, with exudate and the formation of adhesions. He further states that the real gravity of hematocele lies in its susceptibility to infection. "Given a mass of blood mixed with fibrinous exudate and in intimate contact with the intestinal walls, infection by the ubiquitous colon bacillus is a natural sequence and the conversion of this clot to a pulvic abscess is naturally a common occurrence." He states, moreover, that in most cases the infection is of such low grade that the tissues do not break down, but perimetritis occurs.

The possible analogy of peritoneum to pleura as regards its reaction to blood was further explored by Sparks and David,[13] in 1929. Basing their experiments upon those of Allen, they injected various amounts of autogenous blood and various amounts of broth culture of staphylococci, streptococci, and colon bacilli into the peritoneal cavity of dogs, rabbits and guinea-pigs. Peritonitis was produced only by the streptococci in rabbits and in the control animals the incidence of peritonitis was the same as in those receiving blood. Dogs and guinea-pigs were resistant in all cases. In the experiments of Sparks and David the dogs received twenty to 100 cubic centimetres of blood and ten cubic centimetres of broth culture, the rabbits three cubic centimetres of blood and three cubic centimetres of culture, and the guinea-pigs one cubic centimetre of blood and one centimetre of culture. The authors concluded that autogenous blood together with varying types of pathogenic organisms injected into the peritoneal cavity of dogs, rabbits and guinea-pigs does not predispose to the production of peritonitis.

Hermann[6] also attempted to use blood to aid in the production of peritonitis in rabbits. He found that attempts at modifying the virulence of the fecal flora by incu-

* Read before the Philadelphia Academy of Surgery, May 2, 1932.

bation with rabbit's blood or by the simultaneous injection of blood with organisms were unsatisfactory. He stated that the rabbits died more consistently when blood was added, but necropsy did not show peritonitis. No protocols were published of his experiments on the effect of the addition of blood.

From the data in the literature it is difficult to evaluate the effects of blood in the peritoneal cavity on the production of experimental peritonitis. It has never been shown that the presence of blood in the peritoneal cavity has any effect upon the production of peritonitis.

The effect of blood in the peritoneal cavity without infection has been studied by Sabin and absorption rates have been studied by Florey and Witts.[4] Sabin has shown that the presence of blood in the peritoneum sets up a mild peritoneal reaction into which macrophages soon enter to take up and phagocytize the red blood-cells. The contri-

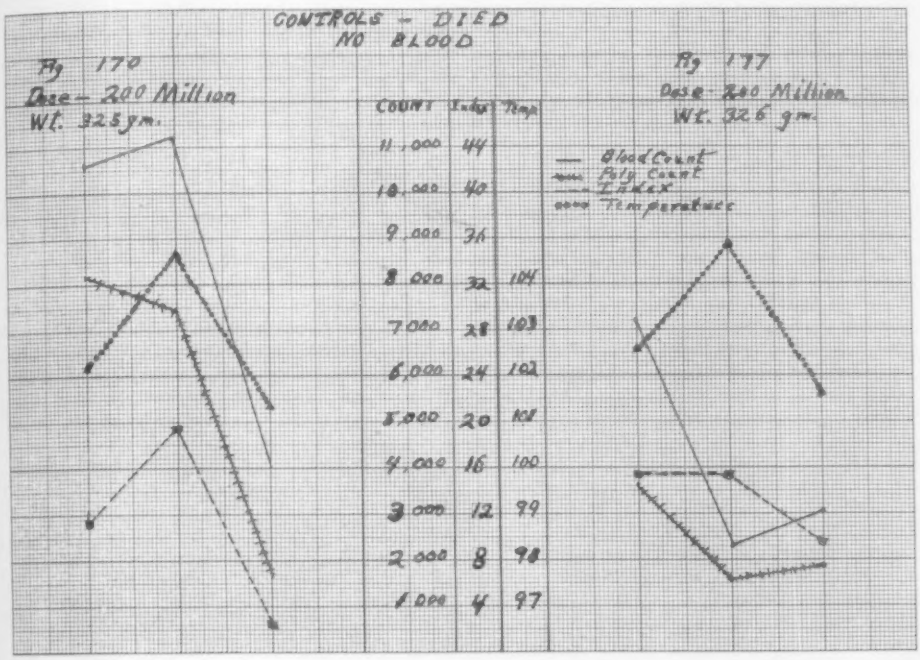

FIG. 1.

bution of Florey and Witts is of value in that they demonstrate the slowness of complete absorption of blood from the peritoneal cavity. Thus even relatively small amounts of blood are not completely absorbed for at least forty-eight hours. They, too, cite the danger of infection, mentioning the death of several animals from septicæmia after septic punctures of the abdominal wall. They demonstrated blood to be absorbed via the thoracic duct at a steady slow rate. They believed that the rate of absorption of red cells was influenced by the intra-abdominal pressure and by the depth of respiration. Sweet and Smythe,[16] in 1921, demonstrated similar facts concerning the absorption of blood from the peritoneal cavity.

Many foreign substances have been studied in relation to the production or treatment of peritonitis. Steinberg and Goldblatt[15] have demonstrated that any mechanism which decreases absorption from the peritoneal cavity in the presence of infection within that cavity favors the development of a peritonits. Any mechanism which permits of normal or increased absorption is associated with recovery of the animal and failure to produce a typical peritonitis. Absorption was determined in terms of the number of

organisms recovered from the peripheral blood and the thoracic duct lymph. These authors showed that recovery was associated with bacteræmia, but in the development of peritonitis no organisms could be recovered from the blood and only few from the lymph. Gum tragacanth was used to decrease absorption and was uniformly associated with the development of fatal peritonitis.

Bruce Morton[9] has, moreover, shown that a plastic exudate of any kind, excited by organisms, or by irritating chemicals, such as turpentine, markedly decreases absorption.

Various other methods of interfering with absorption so as to favor the production of peritonitis have been applied. Gum tragacanth has been used most frequently in this connection in the production of experimental peritonitis. Hermann obtained a higher incidence of peritonitis in experimental animals as a result of the injection of living bacteria in those animals which had received a previous injection of killed organisms.

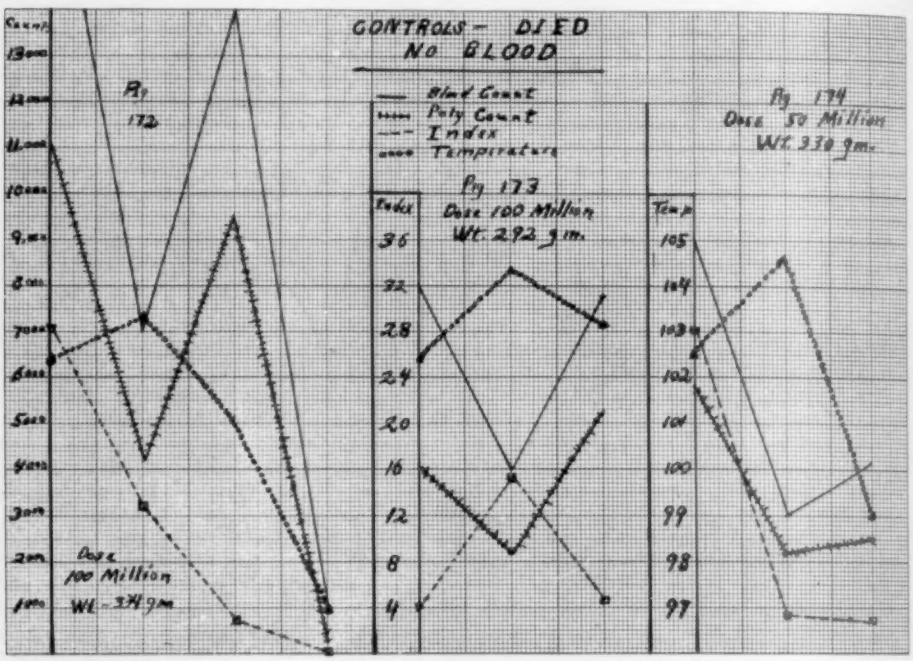

FIG. 2.

He believes that this is due to an increased local reaction rather than to a decrease in absorption. Hypertonic glucose and saline solutions have been studied by Reschke,[11] in 1921, as a possible means of decreasing absorption from the peritoneal cavity. The introduction of eight to nine grams of dry glucose placed in the peritoneum of rabbits through a laparotomy wound resulted in a decreased absorption of bacteria and toxins. Since high concentrations of sugar act as a bacteriostatic agent; it is difficult to draw conclusions from his results.

Starling and Tubby,[14] in 1894, as well as Orlow,[10] in 1895, showed that absorption is slowed in proportion to the concentration of organic material of fluids placed in the peritoneal cavity. These authors pointed out the fact that serum is very slowly absorbed from the peritoneal cavity.

From the foregoing results one would expect that blood should decrease absorption from the peritoneal cavity, since it sets up a local reaction and simultaneously increases the protein or organic content of the injected fluid.

From the previously cited experiments one would expect that these factors would favor the production of peritonitis when organisms are injected with or subsequent to the injection of blood.

Material and Methods.—Since Meleney[7] has found that the colon bacillus is the organism most commonly found in peritonitis, we have used this organism throughout these experiments. Guinea-pigs were chosen for these experiments because they were found to react more uniformly than other laboratory animals.

In our early experiments two strains of colon bacilli isolated from the peritoneum of a patient operated upon for a ruptured appendix were used.

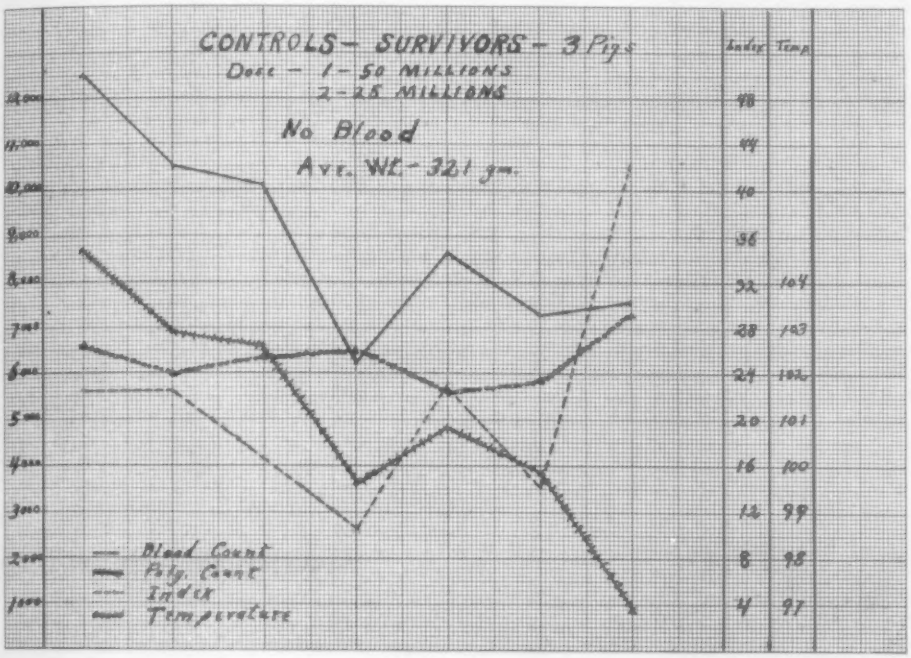

FIG. 3.

The results from the experiments using these strains were quite variable. Similar results were found using a strain (C-20) grown through several generations on laboratory media. Experiments with this strain, using larger or smaller amounts of broth culture, seemed to show that peritonitis and death would occur in a certain number of cases, but even the largest doses occasionally failed to produce peritonitis. Smaller doses might have the desired effect on one day and fail to produce peritonitis on the next. This confusion led to the employment of a wide range of dosage of organisms with inconclusive results.

In the earlier experiments two important factors were not controlled. Known amounts of broth cultures were used without regard to the number of bacteria present. There may be a wide variation in the bacterial count of broth cultures, ranging from 50 to 400 million bacteria per cubic centimetre in

the case of the colon bacillus. In order to control the number of bacteria used, a Gates turbidimeter was employed and all doses determined in terms of millions of bacteria.

The other factor not controlled in the earlier experiments was the variability of the toxicity of the strain used. It was desirable to have on hand a strain in which a fairly constant minimal lethal dose would always produce peritonitis. Various strains in the Pepper laboratory of the University Hospital were tested and two fairly satisfactory strains were found. Dr. Frank Meleney,[8] of New York, kindly contributed two other strains, one of which was found very satisfactory. However, we noted that there was much vari-

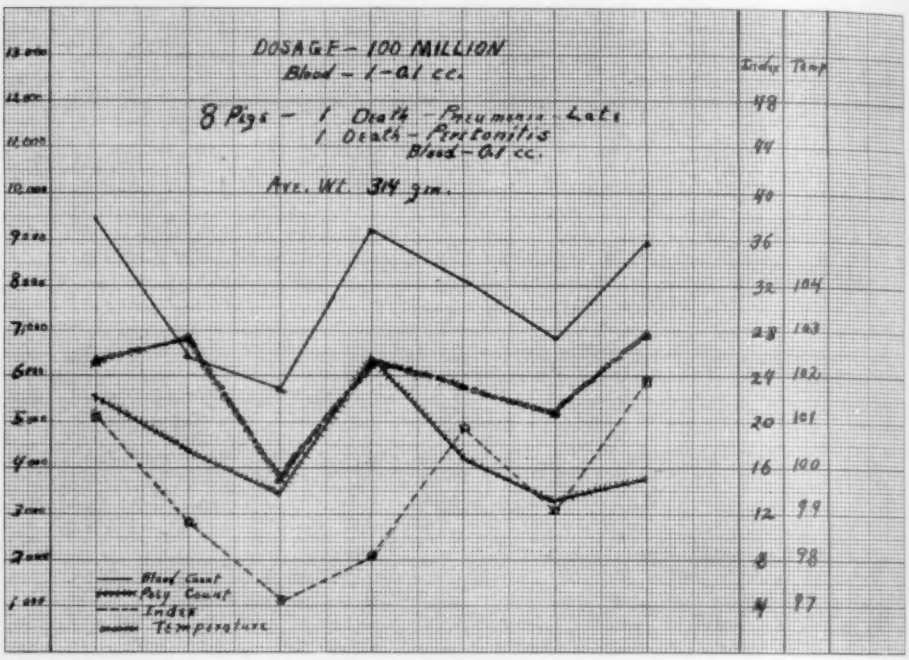

FIG. 4.

ability in the toxicity of the strains tested from Pepper laboratory, although they satisfactorily produced peritonitis. We had noted the development of substrains in most of the strains we had used, but we attached little significance to this phenomenon. Doctor Meleney called our attention to the significance and importance of the development of substrains in relation to variability in toxicity.

Substrain development, as we interpret it, is not the well-known dissociation of bacteria into smooth, rough and intermediate colonies, as described by Theobald Smith and others. There seems instead a definite separation into two substrains, and this seems to occur at any time as the organisms are growing or transferred on artificial media. One substrain is glistening white on its surface and opaque to transmitted light. This substrain of colon bacilli is always toxic when produced in a toxic strain. The other is dark on its sur-

face, but readily transmits light. It may be almost entirely non-toxic. Whenever this separation into substrains occurs and the non-toxic out-number the toxic colonies, the minimal lethal dose of the injected organisms will be much increased. It is then necessary to subculture from the toxic substrain to restore the toxicity. This explains the necessity of determining the minimal lethal dose of any strain on the day before its use to be reasonably sure that the expected effect will occur.

With these refinements in technic an experiment was devised accurately to determine the value of blood in experimental peritonitis. The minimal lethal dose of the strain used was determined as being slightly below 100

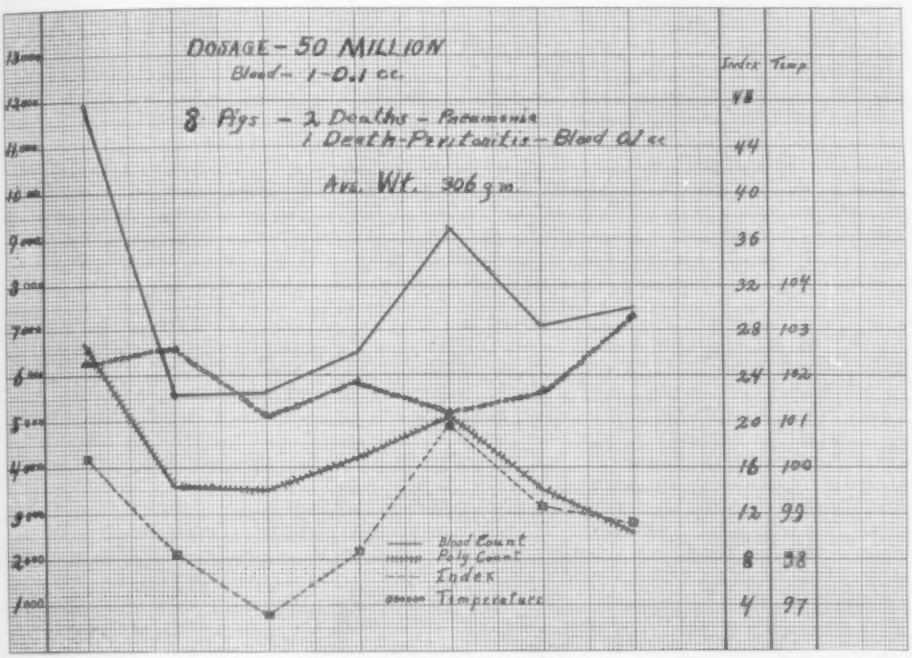

FIG. 5.

million bacteria for a guinea-pig of about 300 grams in weight. Six guinea-pigs were injected with doses of 400, 350, 300, 250, 200, and 100 million bacteria. All the animals died of peritonitis. The last, receiving 100 million bacteria, died in seventy-two hours with a severe plastic peritonitis. The remaining animals died in from two to four hours.

Thirty-four guinea-pigs were used next day, of which ten were used as controls. Blood counts, differential counts, including Schilling indices, were taken from ear veins. Rectal temperatures were taken and smears were made from the peritoneal cavity by needle puncture; all at similar intervals so that all data was collected as nearly simultaneously as possible. Injections were made with a tuberculin syringe through a 22-gauge needle. The animals had been on a uniform diet for some time before the experiment and their weight was nearly uniform. Housing, diet, and all other conditions

were kept uniform during the experiment. When an animal died it was autopsied as quickly as possible, cultures were taken from the peritoneum and microscopical sections were made of its viscera. Blood and peritoneal smears were stained with Ramonowski's stain. The total white blood-cell count and the total polymorphonuclear count were chosen for illustration with the Schilling index as giving the most significant findings. High percentages of monocytes were frequently observed in the differential count, but they were too variable to illustrate.

Autogenous blood was not used in these experiments. Defibrinated sheep's blood collected under sterile conditions was used instead. Broth cul-

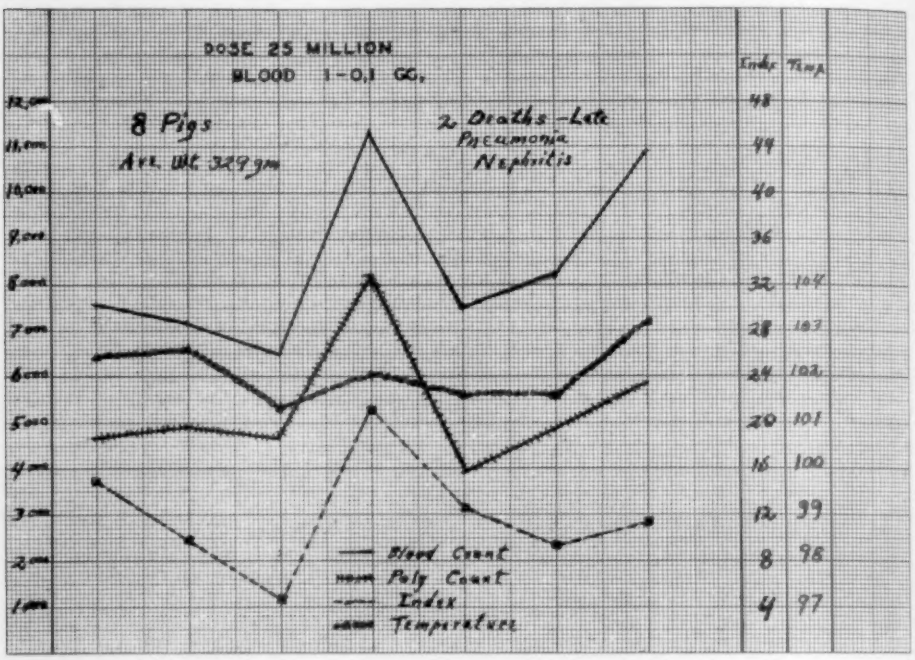

FIG. 6.

tures were thoroughly mixed and shaken, the count determined by the turbidimeter, and the calculated dosage injected simultaneously with blood. Sufficient amount of fluid could not be withdrawn from the peritoneal cavity for cell count without definitely changing dosage relationships, so only very minute amounts were used to make smears.

Results.—In the ten control animals the minimal lethal dose was between fifty and 100 million bacteria. Twenty-five million bacteria did not cause peritonitis or death in either of two animals in which no blood was injected in the peritoneum. When fifty million bacteria were injected, one of the two animals developed peritonitis and died. The six animals receiving 100 million bacteria or more all died of peritonitis.

Twenty-four animals received blood as well as bacteria. These were divided into three groups receiving 100, fifty and twenty-five million bacteria respectively. Each of these groups of eight animals was further subdivided into four groups of two animals receiving 0.1 cubic centimetre, 0.2 cubic centimetre, 0.5 cubic centimetre and one

cubic centimetre of defibrinated sheep's blood injected with the bacteria. Of those receiving 0.2 centimetre or more blood in the peritoneal cavity with the organisms, none died of peritonitis. Four animals of this group died of pneumonia and did not have peritonitis at death as evidenced by a study of microscopical sections. These animals lived for a period of two, six, nine, and eleven days following the injection of the organisms and blood.

Of the animals receiving only 0.1 cubic centimetre of blood with the organisms, one of the two animals receiving 100 million, and one of the two receiving fifty million bacteria developed peritonitis and died on the second and fifth days following the injection. Of the two animals receiving 0.1 cubic centimetre of blood and twenty-five million bacteria one died of pneumonia seven days after receiving the intraperitoneal injection. The mortality and occurrence of peritonitis are illustrated in Table I. When sufficient blood was injected with the organisms (0.2 cubic centimetre or more) the animals did not develop peritonitis even when a dose which killed all controls was injected.

TABLE I

Gross Mortality

Controls

Dosage	200 M	100 M	50 M	25 M
Animals	2	4	2	2
Peritonitis	2	4	1	0
Deaths	2	4	1	0

Experimental

a. 100 M Organisms

Blood	1 cc.	0.5 cc.	0.2 cc.	0.1 cc.
Animals	2	2	2	2
Peritonitis	0	0	0	1
Deaths	0	1	0	1

b. 50 M Organisms

Blood	1 cc.	0.5 cc.	0.2 cc.	0.1 cc.
Animals	2	2	2	2
Peritonitis	0	0	0	1
Deaths	1	0	1	1

c. 25 M Organisms

Blood	1 cc.	0.5 cc.	0.2 cc.	0.1 cc.
Animals	2	2	2	2
Peritonitis	0	0	0	0
Deaths	0	0	1	1

In the controls which died (Figs. 1 and 2) there was a general tendency to a temporary rise of two to three degrees Fahrenheit, in temperature, followed by a drop to below the normal level as the animal approached death. The Schilling index dropped in all fatal cases. Occasionally there was a temporary rise before the sudden drop occurred. The percentage of polymorphonuclear cells was not markedly disturbed in the fatal cases, although there was a drop in total count in nearly every instance.

In the three surviving controls (Fig. 3) the temperature was not so greatly altered. There was a temporary drop in the nuclear index, which later rose to above the normal level. There was a rise in the polymorphonuclear count at the end of twelve hours, but this dropped to a point well below normal by the end of eighty-four hours. The total

count rose rapidly after the injection and later dropped to the normal level. The discrepancy between the total count and the polymorphonuclear count represents a rise in the lymphocytes which continued to remain high.

The animals receiving 0.2 cubic centimetre or more of blood and 100 million bacteria showed a primary drop in temperature, Schilling index and total white blood-cell count, but there was a rapid return to normal with no disturbance of the polymorphonuclear percentage. (Fig. 4.). One of the animals receiving 0.1 cubic centimetre of blood and 100 million bacteria died of peritonitis within forty-eight hours. The findings in this animal were in general similar to the controls who died of peritonitis.

The curves obtained from the animals receiving fifty and twenty-five million bacteria with 0.2 cubic centimetre or more of blood are quite similar to that obtained from the corresponding group receiving 100 million bacteria. (Figs. 5 and 6.)

The high incidence of pneumonia (five of thirty-four) can be explained either on the bases of intercurrent respiratory infection, or upon the fact that the organisms, quickly passing from the peritoneum, set up foci in the lungs.

Peritoneal smears showed that in the fatal cases of peritonitis bacteria increased rapidly. In the control animals surviving, bacteria first increased, then decreased until at the end of eighty-four hours they were usually absent. Animals with blood in the peritoneal cavity showed a very rapid disappearance of bacteria, so that at the end of thirty-six hours no bacteria were found in the smear. The smears of these animals did not contain the large number of bacteria seen in those of the control animals. Table II shows typical findings in the smears of each group.

TABLE II

Peritoneal Smears

Guinea-pig No. 172. Injected intraperitoneally with 100 million bacteria. Result.—Death within twenty-four hours from peritonitis.

	2 hrs.	4 hrs.	12 hrs.
Polymorphonuclear cells	28	63	many
Lymphocytes	3	0	0 per H.P.F.
Red blood-cells	0	40	many
Macrophages	0	0	0
Bacteria	7	many	innumerable

Guinea-pig No. 171. Injected intraperitoneally with twenty-five million bacteria. Result.—Survived.

	2 hrs.	4 hrs.	12 hrs.	36 hrs.	60 hrs.	84 hrs.
Polymorphonuclear cells	3	115	47	84	53	3
Red blood-cells	4	30	0	0	0	0
Macrophages	0	3	4	14	31	31
Bacteria	1	many	30	5	50	0

Guinea-pig No. 179. Injected intraperitoneally with 100 million bacteria and one cubic centimeter of blood. Result.—Survived.

	2 hrs.	4 hrs.	12 hrs.	36 hrs.	60 hrs.	84 hrs.
Polymorphonuclear cells	44	222	150	32	67	3
Red blood-cells	137	832	61	103	22	3
Macrophages	0	0	4	2	6	0
Bacteria	1	9	2	0	0	0

Only one culture of the peritoneal cavity of autopsied animals was sterile and this was one of the animals receiving blood which died of pneumonia. The animals receiving

blood seemed to have less growth in the culture, but too many extraneous factors enter here to draw any conclusions from this fact.

The pathological sections of these animals were interesting. All showed mild nephrosis, cloudy swelling of the liver and acute splenitis. In the animals dying with peritonitis there was marked swelling and œdema of the peritoneum with occasional subserous infiltrations. Pneumonia was diagnosed only when the alveolar spaces were filled in the stage of either red or gray hepatization, since all lungs showed some engorgement and filled capillaries. All adrenals showed poorly stained cells with vacuolization. Some of the adrenals showed derangement of architecture as well and this was especially true when peritonitis was the cause of death.

In order to determine whether dilution of the injected organisms by blood was responsible for the variation in the results seen in the two groups of animals, a third group of six animals was used. These animals received 100 million bacteria diluted with 0.1 cubic centimetre to one cubic centimetre of sterile broth. All these animals died of peritonitis within forty-eight hours.

Discussion and Conclusions.—It would seem from these results that blood injected with organisms not only gives no predisposition to peritonitis but offers a moderate degree of protection against it, at least in the case of the colon bacillus. The control animals receiving a minimal lethal dose all died, yet only two of sixteen receiving a minimal lethal dose with varying amounts of blood died from peritonitis, and these animals received a small amount of blood. Certainly doses below the minimal lethal dose were not raised to minimal lethal by the employment of blood. That this effect was not the result of mechanical dilution was later proven by the addition of broth in varying quantities to minimal lethal doses of bacteria without effect. Peritoneal smears also indicate that blood seems to hasten the disappearance of bacteria from the peritoneum. This may be by reason of greater rapidity of absorption, or by increased rapidity of destruction of the bacteria. This power of protection is not sufficiently great, nor can analogy be drawn with sufficient clarity to human peritonitis to justify its clinical application in any way at present.

The results from these experiments would lead one to believe that the pleura and peritoneum as serous membranes do not respond in a similar manner to the presence of blood introduced with organisms, since Allen has shown that the addition of a small amount of blood increases the incidence of empyæma of the pleural cavity when certain organisms are injected.

Many thanks are due to Dr. F. B. Lynch, of the Pepper laboratory of the University of Pennsylvania Hospital, for his valuable suggestions and constant coöperation in preparation of cultures. We are also indebted to Dr. George Muller, whose suggestions and tolerance have made this work possible. The constant interest and supervision of Dr. I. S. Ravdin are also sincerely appreciated.

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TRAUMATIC ULNAR NEURITIS

WITH ESPECIAL REFERENCE TO THE LATE OR TARDY ULNAR PARALYSIS

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The lesions in which a disturbance of the normal relation between the ulnar nerve and its nerve bed exists may be grouped under the general heading of "Traumatic Neuritis." In considering lesions of the ulnar nerve under this classification, gross injuries may be excluded and attention confined to those cases in which trauma in the region of the elbow has resulted in the gradual onset of a neuritis.

By virtue of its location behind the elbow-joint, the ulnar nerve is subject to many potential disadvantages. Owing to its short course in that location, the nerve is slightly stretched with each motion of flexion but intrinsic elasticity and mobility allow it to undergo these momentary changes without suffering any damage. This compensatory mechanism may be disturbed if the nerve itself is traumatized or if the bed on which it lies be distorted in any way. Under such circumstances, a neuritis is induced by a repetition of normal movements—movements which otherwise would produce no untoward effect.

Exaggerated mobility, an anomaly which exists in a certain unknown number of individuals where the hypermobile nerve slips forward on the epicondyle, may also affect the ulnar nerve adversely. If the dislocation becomes complete and occurs with every movement of flexion, the nerve is almost certain to undergo some damage and a "friction neuritis" be sustained. Platt has distinguished the following clinical groups in this series of lesions and has outlined them as follow:

(1) *Primary neuritis:*
- (*a*) Following simple contusions
- (*b*) Complicating:
  - (i) Internal epicondylar fractures
  - (ii) Supracondylar fractures
  - (iii) Dislocation of the elbow

(2) *Secondary neuritis:*
- (*a*) Complicating:
  - (i) Fractures of the lower end of the humerus
  - (ii) Dislocations of the elbow-joint

(3) *Delayed neuritis:*
- (*a*) With resultant late ulnar palsy as the sequel of external condylar fractures
- (*b*) Following recurrent dislocation of the nerve. It is with this third group of so-called delayed neutritis with the late ulnar palsy that we have to do.

It is believed that Duchenne was familiar with the condition, but as far as can be definitely ascertained, it was first described by Panas, in 1878. He described the lesion in an individual twelve and one-half years after his original injury about the elbow. Broca and Mouchet, in 1899, presented a most comprehensive investigation of the subject in the form of a study of the nerve lesions complicating certain fractures of the lower end of the humerus. Mouchet himself, in 1898, in an earlier paper, had drawn attention to this delayed type of ulnar nerve lesion and had realized that the injury which preceded it was almost invariably a fracture of the external epicondyle of the humerus. Since that time, Mouchet has made several valuable additions to this subject. Prior to 1900, cases were reported by Bowlby, Weber, Guillemain and Mailly and to this period belongs the first of Mouchet's illuminating contributions. More recently, Platt has reviewed the literature and presented several cases of late ulnar paralysis successfully treated by the method of anterior transplantation of the nerve.

Pathogenesis.—In Mouchet's opinion, the classical late ulnar nerve lesion is unlikely to be associated with other varieties of humerus fracture other than those of the external condyle because the development of the paralysis is determined primarily by the existence of a gross cubitus valgus deformity. Now this deformity, in an extreme degree, is a characteristic sequel of the complete external condylar fracture and no other, although an increase in the carrying-angle is not infrequently present after supracondylar fractures or internal condylar fractures. It may be said that the scrutinizing of the radiographs of cases reported in the last decade bears out the accuracy of Mouchet's conception, that the late ulnar nerve lesion is ordinarily a sequel of fractures of the external condyle.

The initial injury is sustained in early life and usually between the ages of two and ten years. In the typical case, the fracture involves the external condyle of the humerus with the line of cleavage running obliquely into the elbow-joint. This is a familiar fracture in children and one which gives rise to difficulty owing to the tendency of the large fragment to be turned on its axis by the pull of the extensor attachments. It appears to be the rule for the fracture to unite by fibrous tissue only. In many cases, the functional result as regards joint function and mobility is fairly satisfactory. The cubitus valgus usually manifests itself at a comparatively early stage but often excites little or no comment at the time. In adult life, the distortion is always conspicuous and is due to the irregular epiphyseal growth being added to the initial displacement already present in the condyle. There is what may be termed a "latent period" in this condition, for, in about 75 per cent. of the recorded cases, the interval between the initial injury and the onset of the first signs of nerve involvement is not less than ten years.

Latent periods of thirty years are not uncommon and in the case herein reported the intervening time was twenty years. As a rule, during this time no change in the elbow is noted other than the steady increase in the degree of the deformity which reaches its maximum with the cessation of growth of the epiphyses. The cubitus valgus is a striking deformity and with the distortion of the lower end of the humerus gives a false impression of overgrowth of the internal condylar region. It is this appearance which has so

often been responsible for the erroneous clinical diagnosis of "old fracture of the internal epicondyle." The ulnar groove is found to be relatively shallow and in it the tender, thickened nerve trunk appears to lie in an unusually exposed and superficial position.

Neuropathology.—Grossly, the nerve trunk is swollen, often irregularly, along a portion of its course. This thickening may extend as far as two inches proximally and distally to the ulnar groove. In the early stages of compression, the nerve is soft, succulent and hyperæmic in appearance and may contain lymph between its bundles. In the later stages, it becomes firmer from the overgrowth of fibrous tissue and local induration may become more marked with the formation of a spindle-shaped neuroma.

On microscopical examination, the picture of a chronic interstitial neuritis may be seen. The peri- and endoneural sheaths show a greater or less degree of infiltration with round cells and proliferation of the connective tissue and endothelial cells. The vessels are congested and their walls filled with cells of various kinds, plasma cells, lymphocytes and polymorphonuclears predominating. As one passes to the later stage of the process, connective-tissue overgrowth assumes the chief rôle, and the cellular infiltration becomes less marked. The nerve fibres themselves may be pressed upon by the lymphocytic infiltration or the overgrowth of the fibrous tissue and undergo changes similar to those of a parenchymatous neuritis. Fortunately, however, even though there is degeneration of the medullary sheaths of the nerves, the axones tend to persist, and thus the function is rapidly restored once the inflammatory products are completely removed.

Symptomatology.—The late neuritis of the ulnar nerve does not differ in symptomatology from the other forms of progressive neuritis. The symptoms arise insidiously and progress steadily. The neurological symptoms in the initial phase will vary with different individuals. As is usual, with compression, the motor fibres are more vulnerable than the sensory fibres and for that reason motor symptoms dominate the clinical picture and often precede any evidence of sensory involvement. Usually there is an atrophic paralysis of gradual development with changes in the electrical excitability corresponding to the degree and duration of the muscle degeneration. The sensory symptoms, both subjective and objective, may be very slight and when present are typically along the course of the ulnar nerve distribution. Even in the advanced cases, the anæsthesia is of the epicritic type, the protopathic sensibility being well-preserved. The objective signs progress from those of an incomplete nerve block to evidence of a complete interruption whence paresis and atrophy of the hand musculature are soon manifest.

In the absence of pain, this scarcely perceptible disturbance of tactile sensibility may be overlooked and lead to the suspicion of progressive muscular atrophy, and especially so since the wasting of the small muscles of the hand is slowly progressive. Here, however, the absence of fibrillary twitchings and the strict limitation of the atrophy to the ulnar nerve distribution, together with the disturbances of sensibility, should be enough to make the diagnosis clear.

With interruption of the ulnar nerve conduction at the elbow, a well-recognized picture will be seen as follows:

(1) Analgesia or loss of protopathic sensation of the fifth finger and the ulnar border of the palm, dorsal and palmar, but seldom of the ring finger; anæsthesia to light touch (loss of epicritic sensation) of the ulnar side of the dorsum of the wrist and palm, of the dorsal and palmar aspects of the hand and of the little and ring fingers.

(2) (*a*) Paralysis of the flexor carpi ulnaris causing weakness in flexion and in ulnar adduction of the wrist.

(*b*) Paralysis of the inner half of the flexor profundus digitorum, with resultant weakened hand-grasp, especially in the ring and little fingers.

(*c*) Paralysis of the two inner lumbricales, all of the interossei and hence loss of adduction and abduction of the fingers, with flexion of the last two phalanges in each finger and hyperextension of the metacarpo-phalangeal joint, giving the "claw-hand." The interosseous spaces become very evident as a result of atrophy of these muscles.

(*d*) Paralysis of the short muscles of the fifth finger; of the inner group of the short thumb muscles (adductor transversus and adductor obliquus) and the deep portion of the flexor pollicis brevis and palmaris brevis.

Treatment.—The treatment will have to satisfy the two canons of the ideal neurolysis: First, the course of the nerve must be shortened, and secondly, the nerve must not be placed where scar tissue will reform and compress it. It is obvious that the only treatment indicated to relieve the condition is surgical interference in an endeavor to free the nerve of compression in the medial epicondylar groove. Mouchet, in his article in 1914, outlined four methods of procedure as being worthy of consideration. The first method was merely a simple freeing of the nerve from its bed and was performed by Potherot, in 1897, in Mouchet's first case. This type of intervention is open to serious question since by merely freeing the connective tissue about the neural groove without any other procedure one invites the formation of more scar tissue and the prime purpose of the operation is defeated. The second method consisted in the gouging out of a posterior condylar groove and placing the ulnar nerve in this newly formed channel. This procedure is criticized for two reasons: first, because it is unwise to replace the nerve in a freshly prepared bed where fibro-osseous scar tissue will form without expecting more compression of the nerve and further trouble; secondly, the course of the nerve is not shortened to any appreciable degree. A third method, which has not been widely used and which sought to correct the cubitus valgus at the same time as the nerve compression, was a supracondylar osteotomy of the lower end of the humerus with the removal of a triangular wedge. The fourth method, and the one which has much to recommend it not only because it satisfies the postulates of a neurolysis but also because of its relative simplicity, is that of transplantation of the ulnar nerve from the ulnar groove anteriorly to the medial epicondyle. This method has proven uniformly successful.

Case Report.—E. P., a white German housewife, aged twenty-two years, was admitted to the Surgical Service of Dr. John F. Connors at the Harlem Hospital Sep-

tember 30, 1931, with the complaint of progressive weakness of the right hand, contracture of the fingers and diminished sensation of the fourth and fifth fingers of eight months' duration. In January, 1931, she noticed for the first time that she could not fully extend the fourth and fifth fingers and that power and grip in those members were becoming increasingly weaker. This loss of power was especially noticeable when she attempted to

FIG. 1.—Photograph taken prior to operation showing the marked degree of cubitus valgus, contracture of the fingers and atrophy of the intrinsic musculature of the hand. (Photograph taken October 1, 1931.)

do her housework and tried to lift objects with that hand. She states that the weakness has persisted longer than the anæsthesia and the contracture; in fact, it was the sensation of numbness and tingling in the fingers that brought her to the hospital for relief. There has never been any swelling or pain. Her past history is irrelevant except for an injury she received in the region of her right elbow at the age of two years and for which she

FIG. 2.—Photograph showing dorsal aspect of the right hand and the extent of contracture of the fingers as compared with the normal hand.

was treated in a surgical clinic in Germany (1911). She was a healthy young woman with a marked cubitus valgus deformity of the right elbow and atrophy and contracture of the last two fingers of the right hand. (Figs. 1 and 2.) The hand shows the typical picture of the lesion resulting from pressure on the ulnar nerve at the elbow with characteristic analgesia and anæsthesia of the fourth and fifth fingers; weakened hand grip owing to a partial paralysis of the flexor profundus digitorum; hyperextension of the

metacarpo-phalangeal joints with the "claw-hand"; loss of the power to abduct and adduct the fingers with atrophy of the interossei.

Laboratory findings.—Temperature on admission, 99.0; pulse: 80; urinalysis: negative; blood Wassermann: negative; hæmoglobin: 90 per cent.; red blood-cells: 4,650,000; white blood-cells: 10,200; 80 per cent. polymorphonuclear leucocytes.

Radiographical findings reported an old fracture of the external condyle with a marked cubitus valgus deformity. (Figs. 3 and 4.) A photograph was also taken of the affected hand to show the extent of the atrophy of the intrinsic hand musculature. (Fig. 5.)

Despite the marked degree of deformity present at the elbow the flexion and extension were remarkably good.

A pre-operative diagnosis of tardy ulnar paralysis was made and operation decided upon in order to free the nerve and transplant it. October 1, 1931, operation was performed as follows: A seven-inch incision was made over the medial epicondyle extending

FIG. 3.

FIG. 4.

FIGS. 3 and 4.—Radiographs of the affected extremity showing the characteristic picture of an old fracture of the external condyle of the humerus with a partial rotation of the fragment. The original trauma causing the fracture occurred twenty years prior to the development of symptoms of ulnar palsy.

about three and one-half inches above and below that point. The soft tissues were divided and all bleeding points secured. The ulnar nerve was seen in its usual place and located at a point where it entered the ulnar groove of the medial epicondyle. A tape was then placed about the nerve trunk. On following the nerve along its course, a firm band of fibrous tissue was seen, causing the nerve to be adherent to the groove of the epicondyle. This was freed and the nerve trunk observed to be enlarged to about twice the normal diameter. At this point, for about one inch, the nerve was seen to be red, injected and somewhat more succulent in appearance. It was freed from the groove and brought anteriorly to rest upon the common origins of the flexors of the forearm. The arm was then extended to full extension and the nerve found to be loose and freely movable. For this reason it was not deemed advisable to divide the flexor carpi ulnaris. In order to prevent dislocation of the nerve, a tunnel was fashioned from the deep layer of the superficial fascia of the forearm and the nerve enclosed within this. The super-

ficial fascia was then brought together with No. 0 plain catgut and the skin edges closed with one continuous horsehair suture.

Owing to the fact that the patient was four months' pregnant, the operation was performed under local anæsthesia using 1 per cent. novocaine to infiltrate.

Her post-operative course was entirely satisfactory and she was discharged from the hospital on her third post-operative day. An inspection of the wound at that time

FIG. 5.—Photograph taken on November 23, 1931, on the fifty-third day after the anterior transplantation of the ulnar nerve. The claw-like appearance of the hand has largely disappeared, the interosseous spaces are not so prominent and complete sensation has returned to the ring finger.

showed the suture line to be intact and without infection. She was seen in the follow-up clinic on the ninth post-operative day and at that time the sutures were removed, the wound having healed by primary union.

She was seen October 14, 1931, and a note made that "the claw-like appearance of the hand had decreased somewhat. The patient states that there has been some return

FIG. 6.—Post-operative photograph taken to demonstrate the increase in power to flex fingers and the grip present after transplantation of the ulnar nerve. At the present time, there is little difference in power in the two hands. (Photograph taken December 21, 1931.)

of power in the affected hand." Slow muscle stimulation by means of the sinusoidal current was started.

November 6, 1931, the following note was made: "Sensation has returned to the fourth finger. The grip has returned in her hand so that she can now do her housework without difficulty. The interosseous spaces are not so prominent, indicating some return

in size of the interossei muscles. The claw-like appearance has largely disappeared. There is still a sensation of numbness in the fifth finger but the patient thinks that this is less than prior to her operation. There is still a prominence in the web-space between the thumb and the index finger."

At the time of her last visit, November 23, 1931, the hand presented objectively the same picture as that reported on November 6. She has been given sinusoidal treatments three times weekly and advised to use her hand as much as possible. This régime will continue for at least six months.

The striking feature in the post-operative course has been the diminution in the contracture of the hand and the rapidity of the return of power in that member.

CONCLUSIONS.—(1) The lesions in which a disturbance of the normal relation between the ulnar nerve and its nerve bed exists may be grouped under the general heading of "traumatic neuritis." The clinical entity of late ulnar palsy is then to be regarded as being within this group.

(2) The condition is not common but is easily diagnosed in the light of a history of an old fracture about the elbow followed years later by increasing weakness and atrophy of the hand. The original fracture is almost invariably a fracture of the external condyle of the humerus which was sustained in childhood.

(3) Of all the methods of surgical intervention, that of transplantation of the ulnar nerve is by far the simplest and has given the most striking results.

(4) In the case herein reported, the original fracture occurred twenty years before the development of symptoms and definite objective and subjective improvement was manifest as early as two weeks following the anterior transplantation.

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THE TREATMENT OF SARCOMA OF THE LONG BONES*

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During the past decade and a half, there has been an increasing interest in the subject of bone sarcoma, as manifested by the numerous papers and monographs that have been published both here and in Europe. Four books on the subject have appeared within the last four years, two of them by French authors, and one, the admirable work of Geschickter and Copeland, is based upon a study of a large number of cases observed at the clinic of Doctor Bloodgood at Johns Hopkins Hospital. Yet, in spite of this growing interest and voluminous writing, the treatment of bone sarcoma, especially of sarcoma of the long bones, remains in a most chaotic, unsettled state. The surgeon who, today, has to deal with a sarcoma of a long bone, even though he is acquainted with the literature on the subject, finds it most difficult to decide upon the method of treatment to be employed.

In 1921, at a symposium on bone sarcoma held during the Philadelphia meeting of the American College of Surgeons, Besley, of Chicago, stated that of twenty cases of bone sarcoma that he had treated by amputation, all that he had been able to trace, regardless of the histological type, had died; and that he had performed his last amputation for bone sarcoma. Six years later, a distinguished professor of pathology in New York who had made an extensive study of malignant tumors told me that if he personally were afflicted with a bone sarcoma, regardless of the histological type, even giant-cell tumor, he should have an immediate amputation performed.

Bone sarcoma is such a comparatively rare disease that the average surgeon sees no more than one or two cases, perhaps not even that many, in a year; and the average large city hospital admits not more than four or five cases annually. In the opinion of Forschell there are never more than twenty cases of sarcoma of the long bones in all Sweden at any given time.

It might be supposed that a study of the large amount of material collected by the Bone Sarcoma Registry of the American College of Surgeons would help one to select the best method of treatment; and yet after reading Kolodny's[1] critical review of this material, one must admit that he has gained little of practical value, and that Kolodny leaves one almost as pessimistic as did Butlin more than a generation ago. To quote Kolodny: "In bone sarcoma as in other malignant tumors the question of the therapy is still awaiting its answer. It is a strange fact that with our knowledge of minute details of the histopathology of bone tumors the progress along the practical therapeutic road is almost in the same stage that it was in some fifty years ago. As a rule malignant bone tumors are fatal and we know of no therapeutic method to prevent death from this disease."

* Observed in the Bone Sarcoma Department of the Memorial Hospital and the Hospital for Ruptured and Crippled of New York.

Crile,[2] in his recent paper on the Treatment of Malignancy, based on an experience in 7,390 cases of malignancy, discusses the treatment of malignant tumors of bones in a few lines, as follows:

> Exclusive of carcinoma of the jaw, we have seen 161 cases of malignant disease of bone. It is still uncertain whether a primary malignancy of bone should be treated by X-ray or by surgery, but two things are certain: First, if an operation is performed, it should be preceded and followed by X-ray radiation; and second, if the condition is in a limb, amputation should immediately follow radiation, provided the condition is not inoperable. As for metastatic tumors, palliative treatment by the X-ray is the only therapeutic measure. Radium is contra-indicated as it would destroy the periosteum, and necrosis would follow.
>
> The data which are being accumulated by the Registry of Bone Sarcoma of the American College of Surgeons may finally lead to a decision as to the relative merits of surgery and of radiation in the treatment of malignant diseases of bone.

In other words, the material of the Cleveland Clinic furnishes no help in trying to decide on the best method of treating sarcoma of the long bones.

Turning to the foreign literature, we find that Nové-Josserand and Tavernier,[3] in their book on Malignant Tumors of Bones, state that they are not impressed with the results obtained by radiation; that this method is rarely employed in a systematic manner, and that, so far, it has usually been limited to inoperable cases after failure of surgical treatment. In a later paper, however, one of these authors (Tavernier[4]) reaches a more favorable conclusion as to the value of irradiation in the treatment of osteogenic sarcoma. He states: "All the osteosarcomas that I have treated by surgical methods, even the most radical, have died of metastases after varying periods not exceeding five months. Only one has survived the period of five years, and in this case the diagnosis was doubtful; I myself considered it a benign tumor at the time of operation, although on histological examination it presented features of a spindle-cell sarcoma; the prolonged survival after resection makes me doubtful of the diagnosis. In view of these disastrous results I have tried radio-therapy in ten cases: three have remained well for three years, one for one year, three are recent cases, and three proved failures."

In the most recent book written on Tumors of Bones, Sabrazes, Jeanneney and Mathey-Cornat[5] express the opinion that every patient afflicted with osteogenic sarcoma succumbs to the disease within a few months to two or two and one-half years, and that a mutilating operation is but very rarely followed by a longer survival. As regards the treatment of osteogenic sarcoma by irradiation, they believe the present statistics are too incomplete to justify any conclusions. Contrary to the opinion expressed by Tavernier, these authors state: "While certain osteogenic sarcoma which we ourselves have treated by irradiation have shown temporary amelioration for a month or two, they have thereafter become rapidly worse, the disease recurring and becoming generalized."

A study of the end-results obtained at Johns Hopkins Hospital, cited in the recent book of Geschickter and Copeland,[6] shows that the writers I

have quoted are unduly pessimistic. I believe that a study of the end-results obtained at the Memorial Hospital and the Hospital for Ruptured and Crippled will prove even more convincing, and will help to eradicate the present attitude of hopelessness as regards the prognosis in malignant tumors of the long bones.

Classification.—Before deciding on any method of treatment of sarcoma of the long bones it is important to determine (1) whether we are dealing with a malignant tumor or a benign tumor; and (2) if malignant, what type of tumor it is.

While the ideal classification of bone sarcoma has not yet been reached, that of the Bone Sarcoma Registry of the American College of Surgeons is, perhaps, the best available. For practical purposes, however, it is too complicated and divides the main group of bone sarcomas into too many different types. All the surgeon needs to know is (1) whether the tumor in question is a periosteal or a central sarcoma; (2) whether it is an osteogenic sarcoma or an endothelial myeloma, and (3) if a central sarcoma, whether it is a benign giant-cell tumor, a central malignant sarcoma, a multiple myeloma or a metastatic carcinoma. All the other histological sub-divisions are of little importance in deciding upon the method of treatment in a given case. The idea so widely prevalent that the large variety of neoplasms based upon histological distinctions represent an equally large number of separate diseases or entities is no longer tenable, at least, not in bone sarcoma. Berg,[7] in his fellowship thesis, showed that by injecting the dried virus of the filterable fowl endothelioma tumor into the tibia of Rhode Island Red chicks it was possible to produce five different types of bone sarcoma, including endothelioma, corresponding almost exactly with the different types found in man. If it is possible, as Berg's work has proved, to produce in animals all these different varieties of bone sarcoma by a single extrinsic agent, we can no longer regard these different varieties as different diseases but as different manifestations of a single disease produced by a single agent. This does not necessarily mean that the same method of treatment should be used in these various types of tumors. We have found by experience that certain types of bone tumors (endothelial myeloma and giant cell) are highly sensitive to both irradiation and Coley's toxins, while, on the other hand, others, such as the osteogenic sarcoma with marked new bone formation, are very highly resistant to both. Hence it is important to know before we begin treatment just what type of tumor is present. We know that the tubercle bacillus does not give rise to lesions that are always typical, but that it causes a great variety of clinical manifestations, and that no one method of treatment is suitable for all of them.

While in the majority of cases we are able to make a correct diagnosis from the clinical and röntgenological evidence alone, there is a considerable number, probably from 20 to 25 per cent., in which a correct diagnosis is impossible without the aid of a histological examination. This brings up the question of indications and contra-indications of biopsy.

Biopsy.—The question of performing a biopsy in bone sarcoma for the purpose of establishing the diagnosis is one that is still unsettled. Some advocate a biopsy in every case as part of the treatment, while others, including Ewing, would omit the biopsy altogether or limit it to a very small number of cases. In my opinion the dangers and disadvantages associated with a biopsy have been greatly over-emphasized. The two most frequently mentioned are: (1) Dissemination of the tumor, by means of which some of the cells enter the circulation and cause metastases, and (2) failure of the biopsy wound to heal, resulting in infection, possibly necessitating an amputation.

If the biopsy is performed by the surgeon who is to have the final treatment of the case, one who employs the best operative technic, the danger of infection is extremely slight; furthermore, the possibility of generalization occurring by reason of the biopsy, in my opinion is also very slight, hardly sufficient to offer any serious objection to the operation. Dr. Francis Carter Wood, in his experiments on animal tumors, has shown that the danger of metastasis is not increased by the biopsy; and my experience with human beings supports this view.

As to the exact value of the biopsy, after it has been performed, there is also much difference of opinion. Pfahler and Parry[8] believe that when the expert radiologist is in doubt, the pathologist is also often in doubt; and if the microscopical slides are sent to several equally expert pathologists, the opinions are apt to differ. Furthermore, he quotes Ewing as saying that the röntgenograms are of equal or greater importance than the microscopical section.* Kolodny often finds that with a good clinical history and röntgenograms, one can be as sure of a diagnosis as from seeing the patient, the lesion, the gross specimen and numerous sections, and adds, "Not infrequently a röntgenogram is more decisive than a number of microscopic sections." This opinion has been expressed by many of the leading pathologists as well as Ewing.

My personal opinion is that when trying to make a diagnosis of bone sarcoma, especially in the early stages of the disease, we should not trust to the röntgenogram alone unless the clinical evidence strongly supports it. It is most important that a correct diagnosis be made as early as possible if the treatment is going to be of any avail. While it is often possible in the later stages of the disease to make a positive diagnosis of osteogenic sarcoma from the röntgenogram alone, this is not true in the early stages. Therefore, in trying to make a diagnosis in the early stages, one should take advantage of all that is to be gained from a careful study of the clinical history, the physical examination and the röntgenogram. In a limited number of cases it will be necessary to make, in addition, a histological study of the gross specimen and microscopical sections removed at biopsy.

Two years ago† the opinion was published in the lay press that all that

* I believe that Ewing has usually qualified his statement by "sometimes."

† In connection with the Bone Sarcoma symposium at Baltimore, Md.

was needed to make a correct diagnosis of bone sarcoma was for the family physician to send a film of a suspected tumor to a radiologist and get his diagnosis by return mail. This idea gives a very erroneous impression of the many difficulties associated with the early diagnosis of bone sarcoma. The impracticable side of this plan is well illustrated by the following statement of Bloodgood:[9]

> "A surgical colleague tells me that he has submitted the X-ray of a bone to sixteen consultants and got sixteen opinions. Another informs me that he submitted his case to eight authorities; all agreed on amputation without biopsy, and after amputation the lesion proved to be osteomyelitis of the Garre non-suppurative type."

It is only by a careful weighing of all the evidence including the clinical, röntgenological and pathological, that one is able to reach a correct diagnosis in many of the more difficult cases; and in a certain and fortunately very limited number of cases the most experienced observer will find it impossible to do so with the aids mentioned.

Frozen-section Diagnosis.—Many writers, including Bloodgood and Lewis, advocate making a diagnosis from frozen sections obtained at the biopsy; if the condition proves to be malignant, an amputation is at once performed; if the condition proves to be a benign giant-cell tumor, conservative treatment is employed. Personally, I do not believe that such an important matter as the amputation of a limb should be determined from a microscopical examination of frozen sections of a bone tumor. In many instances the specimen contains so much bone and cartilage that it is impossible to make sections without decalcification. In other cases in which the specimen contains soft tissue only, I find it frequently impossible to tell whether we are dealing with a benign condition or a malignant one. Therefore, I have given up trying to make a definite diagnosis from frozen sections. I believe it is perfectly safe to wait for the paraffin sections; I have seen no harm result from this delay.

A clinical history of rapid tumor growth accompanied by severe pain, even with a doubtful röntgenogram or no röntgenogram at all, may furnish sufficient grounds for an amputation. I have performed an amputation in a considerable number of cases of bone sarcoma without a biopsy, upon clinical and X-ray evidence alone, and in each case the condition has proved to be malignant.

Surgical Treatment.—The treatment of sarcoma of the long bones by amputation dates back to the time when this condition was first recognized as a malignant process, although classified under a great variety of names.

Unfortunately, in the earlier years, and, in fact, until recently, amputation was not performed until the disease had progressed so far that there was little or no hope of saving the patient's life by any method of treatment.

Not until 1920 did we begin to see marked improvement in the results of amputation alone for sarcoma of the long bones. In 1922, Meyerding[10] reported a series of 100 cases treated by amputation; in many, prophylactic-toxin treatment was given, and in some this was supplemented by röntgen

therapy. At the time of the report, 50 per cent. of the patients were living, 16 per cent. over five years.

In May, 1923, at a symposium on Bone Sarcoma by the Association of Surgeons of Great Britain and Ireland, in London, Gask reported a series of fifty-seven cases of sarcoma of the long bones, exclusive of giant-cell tumors, admitted to St. Thomas's Hospital from 1901 to 1921. Out of forty-six cases in which amputation was performed, twelve were alive three years later, and seven more than five years later; one of these died of metastasis to the skull more than six years after amputation.

I believe the improvement in prognosis during the last decade is undoubtedly due to our ability to make an earlier diagnosis by reason of a more correct interpretation of the early röntgenograms and an early adoption of surgical measures (amputation). In our own series the prognosis has improved as a result of combining the systemic treatment with the toxins of erysipelas and *Bacillus prodigiosus* with surgical operation or irradiation.

Disarticulation.—I have performed hip-joint disarticulation for sarcoma in seventeen cases without mortality but with only two permanent recoveries. In one case the recovery was due not to the amputation alone but to the prophylactic-toxin treatment as well.

This patient, a young girl, was operated upon by Dr. William T. Bull, in 1893, for a periosteal fibrosarcoma of the metatarsal bone; an amputation above the ankle was performed. One and a half years later the disease recurred in the stump, and a metastatic tumor the size of a child's head appeared in the popliteal space. Under Coley's toxins the disease showed marked regression; but one year later it began to increase in size and I performed a hip-joint amputation. Within a short time extensive metastases developed in the gluteal region and the condition became quite inoperable. Under prolonged toxin treatment the disease steadily regressed until it had entirely disappeared. The patient is well at the present time, thirty-eight years since the treatment was first begun. In a second case of amputation at the hip by Dr. Stuart McGuire (1917), for round-cell sarcoma (endothelial myeloma) in a boy aged three and one-half years, the patient was referred to me for treatment of extensive, inoperable metastases to the skull (June, 1919); under toxin- and radium-treatment the tumors disappeared and the patient is in fine health today, thirteen years later.

During recent years I have performed very few disarticulations and these only in cases in which the disease occupied the middle and upper third of the femur. In nearly all the cases in which the disease occurred in the lower half of the femur I have found is possible to amputate below the trochanter leaving a sufficient stump to permit the use of an artificial leg. I believe if prophylactic-toxin treatment is given after such an amputaion one will get practically as many permanent recoveries as if a disarticulation had been performed.

In performing an amputation without disarticulation, it is important that this should be done at a point at least four or five inches beyond the apparent extension of the tumor as shown by palpation and röntgen-ray. In a very large number of cases in which we have amputated below the trochanter for periosteal sarcoma of the lower portion of the femur, there has been a re-

currence in the stump in only four cases. In two cases of osteogenic sarcoma of the upper end of the humerus very satisfactory results were obtained by resection and irradiation; both patients are well over ten years.

My first successful result with the toxins in sarcoma of the long bones occurred in 1897, in a young man twenty-seven years of age with an extensive periosteal spindle-cell sarcoma of the tibia, in which the diagnosis had been confirmed by Dr. John Caven, Professor of Pathology of the University of Toronto. Many who had seen the patient before he came to me had advised an amputation. I decided to try the toxins alone.

FIG. 1.

FIG. 2.

FIG. 1.—Spiral fracture of the shaft of the humerus (May, 1923), showing no evidence of a pathological condition at the time of injury.

FIG. 2.—Same case as shown in FIG. 1, this film having been made one year later showing a very extensive endothelial myeloma of the humerus at the site of the fracture. The condition was inoperable at the time of the author's first observation. The case was treated with toxins for two and a half years in addition to two radium-pack treatments. Good recovery was made, the patient being well eight and a half years later, with a useful arm.

Under two months' treatment, the tumor had almost entirely disappeared and the bone cavity had healed by healthy granulations. Just as he was about to be discharged, he contracted a severe attack of erysipelas which started at the site of an old sinus from a previous operation and extended over the entire leg and thigh. The patient made a complete recovery and was discharged from the hospital three weeks later. When last traced, thirty-two years later, he was still in excellent condition with a perfectly useful limb.

I had continued to use conservative treatment (a brief course of Coley's toxins) before amputation in all cases of periosteal sarcoma. However, since 1920, I have come to realize that the osteogenic type, especially that associated with new bone formation, is highly resistant to toxins as well as to irradiation, and that immediate amputation followed by prophylactic toxin treatment offers the greatest hope of benefit.

After amputation or resection for osteogenic sarcoma, Fraser[13] believes in exposing the skeletal outline, the lungs and the mediastinum, to intensive X-rays, concentrated if possible within twenty-four hours, using 250,000 volts and giving a 70 per cent. (sarcoma) dose. He states that this has been responsible, in two cases in which resection was performed, for the prolongation of life. He also maintains that Coley's toxins are of value in preventing or delaying metastases. He feels that the latter, in conjunction with resection, offers a field of possibilities as great if not greater than that of amputation.

Irradiation.—During the past ten years there has been an increasing tendency to refer all cases of bone sarcoma to the radiologist for treatment. The reason for this is obvious: Up to 1920 the results of amputation in malignant periosteal sarcoma were so bad that the surgeon, and, even more, the patient, were ready and willing to turn to any other method of treatment that offered any reasonable hope, especially if such method avoided the sacrifice of the limb. While irradiation was employed soon after the discovery of the röntgen-ray, it was not until the introduction of the high-voltage machine and the acquisition of large amounts of radium that the treatment of bone sarcoma by irradiation was carried out on a large scale.

The impression has been given by some writers, *i.e.*, Evans and Leucutia,[14] that I am definitely opposed to irradiation for bone sarcoma. On the contrary, I was the first to employ X-rays in the treatment of bone sarcoma (in 1902 at the Memorial Hospital) and during the past fifteen years I have made an earnest effort to determine its value in the different types of bone sarcoma. Between 1915 and 1928, practically all the service cases, including those of giant-cell tumor, at the Memorial Hospital were treated by primary irradiation. Having a large amount of radium at our disposal, at first four grams, and later eight grams, a considerable number of cases were treated with the radium pack; this was sometimes supplemented by bare tubes of radon or gold seeds inserted into the tumor. The majority of cases, however, were treated with röntgen-rays by Doctors Herendeen and Duffy. It was hoped that in the event of failure to control the disease by irradiation, a later amputation after prolonged irradiation might yield better results than would an early amputation without pre-operative irradiation. Unfortunately, this hope proved unfounded. In 1928, a careful review of the results obtained in more than 140 cases of primary operable malignant sarcoma of the long bones treated by irradiation showed only four patients alive and well beyond the five-year period. Hence, we have abandoned irradiation as the primary method of treatment for osteogenic sarcoma, and have substituted immediate amputation followed by a course of prophylactic treatment with Coley's toxins.

At the International Cancer Congress in London, 1928, Ewing,[15] who

had long been a strong advocate of primary irradiation for bone sarcoma of all types, gave his views as follows: "When the signs point to a true osteogenic sarcoma of medullary and sub-periosteal, sclerosing, or telangiectatic type, the best treatment is probably immediate amputation, preceded if necessary by a biopsy at the same time. With these cases, radiation seems to have accomplished very little."

On the other hand, we find Pfahler and Parry,[16] in 1931, advocating irradiation for osteogenic sarcoma. However, their report of fifty-seven cases contains only six cases of sarcoma of the long bones well for a period of five years or more; four of these six cases were treated by amputation in addition to irradiation, and one by excision. The only one treated without surgery had no microscopical confirmation of the diagnosis. Therefore, the results in this series were not obtained by irradiation alone but by irradiation *plus surgery*. Had irradiation been continued for a longer period of time, as in the Memorial Hospital series and as is advocated by Holfelder, I am certain that the results reported by Pfahler and Parry would have been much less favorable. In the Memorial Hospital series, primary irradiation was given for a much longer period than one month, and amputation was performed only after failure to control the disease by irradiation; the number of five-year recoveries is exceedingly small, much smaller than in the group treated by primary amputation and prophylactic-toxin treatment.

Holfelder,[17] the Director of the Röntgen Institute of the Surgical University Clinical, Frankfort, whose statistics are frequently quoted, especially by Pfahler, reports twenty-five cases of bone sarcoma treated with deep röntgen therapy during the years 1920–1921 and 1925–1926 (up to June 30). Sixteen of these cases were traced upwards of three years, and the remaining nine for more than two years. Of the sixteen cases, six are stated to have been clinically cured; three of these were under observation for more than five years. In only three of these six cases was the diagnosis verified by histological examination. In six other cases improvement was noted which lasted over a period of from one to two years. Ten patients died of the disease. Of the nine cases that were traced for upwards of two years, seven remained clinically cured at the time of the report; in six of these the diagnosis was confirmed by histological examination. It is important to note that nearly one-third of these cases were giant-cell tumors.

While Holfelder deems the number of cases reported and the period of observation insufficient to justify more definite conclusions as regards end-results, he believes they do warrant the conclusion that the clinical results of röntgen treatment of bone sarcoma, if properly conducted, will certainly not be worse than the best results obtained with radical operative procedures. He states that inasmuch as röntgen treatment of bone sarcomas completely avoids the serious mutilation of radical operation, he feels it a duty, even at this early date, to advocate conservative röntgen therapy for all types of bone sarcoma, in preference to any of the mutilating operations. He goes

still farther than Pfahler and Parry in advocating prolonged irradiation, rather than amputation after a short period of irradiation.

However, I believe Holfelder's series of cases is far too limited in number, and the period of observation too short to influence one in substituting irradiation for amputation in the treatment of osteogenic sarcoma of the long bones.

According to Forssell,[18] radiological treatment alone should not as yet be advised for operable cases of osteogenic sarcoma of the long bones. While pre-operative and post-operative irradiation should be used with conservative operation—this combined method has doubled the proportion of cures at the Radiumhemmet—he doubts whether irradiation prior to or after amputation is of any use. Yet "it may be worth while considering the possibility that a healing process initiated by radiation may in some cases bring about an increased resistance against tumor formation." He urges that tumor treatment, both surgical and radiological, be centralized in the largest hospitals, since special technic and training are so necessary. He estimated that in all the hospitals in Sweden only twenty malignant tumors of the long bones are admitted each year, hence the necessity of concentrating the material.

Undoubtedly, a very large number of osteogenic sarcomas have been treated in this country by primary irradiation during the past ten years, and the statistics of the Bone Sarcoma Registry of the American College of Surgeons should show a considerable number of five-year recoveries, had the method proved successful. As a matter of fact, however, the Registry shows only two cases of osteogenic sarcoma (one of the long bones) cured by irradiation alone; and in one of these cases the diagnosis was based on the clinical and röntgenological evidence alone, and in Doctor Ewing's opinion was by no means positive; he believed the condition simulated a myositis ossificans.

Preliminary Irradiation.—While Bloodgood believes that a brief trial of preliminary irradiation before biopsy entails no risk, personally I have seen several cases in which I believe harm has resulted from irradiating a long bone sarcoma for even a short period of time, *i.e.*, less than one month.

In spite of the improved results from early amputation, the fact remains that at the present time a very large number (in my opinion, the majority) of osteogenic sarcomas are being treated by primary irradiation as the method of choice—and this is true of some of the foremost hospitals of the country.

Treatment of Osteogenic Sarcoma.—In view of the fact that osteogenic sarcoma is highly resistant to both irradiation and Coley's toxins, I believe an amputation should be performed as soon as a positive diagnosis has been made. I do not approve of preliminary irradiation. Within one week of the operation the patient should receive prophylactic treatment with the mixed toxins of erysipelas and *Bacillus prodigiosus*. (Coley.) This treatment can be carried out at home later on by the local physician. The initial dose should be small, not over one-half minim, and gradually increased to the point of producing a moderate reaction, a temperature of 101° or 102°. The injections should be kept up, with occasional intervals of rest, for at least six months; they need not greatly interfere with the patient's routine of life. I believe that the prophylactic toxin-treatment more than doubles the number of five-year recoveries obtained by early amputation alone.

There is a certain type of osteogenic sarcoma now classified as periosteal fibrosarcoma which involves the periosteum alone or the muscular attachments of the periosteum, in which there is little or no bone involvement. This is more benign than the ordinary osteogenic sarcoma. In this type one is justified in trying to save the limb by conservative treatment (local irradiation and systemic toxins). We have under observation at present four cases in which the disease has been held apparently under complete control for three years. In addition there are a few cases of osteogenic sarcoma of the osteolytic type, highly cellular, with little or no new bone production, that have been cured by toxins alone or in conjunction with irradiation.

However, these apparent permanent recoveries under considerative treatment are limited to a certain rare type of osteogenic sarcoma. As a general rule, I believe that early amputation followed by a course of prophylactic treatment with Coley's toxins should be the method of choice in the treatment of osteogenic sarcoma of the long bones.

Endothelial Myeloma or Ewing's Sarcoma.—This type of tumor has been found to be much more amenable to treatment with toxins and radium than has the osteogenic type. It is a type with very definite clinical, röntgenographical and histological characteristics, different from those found in osteogenic sarcoma. As Ewing[19] pointed out, it originates chiefly in the shaft of the long bones, and occurs mostly in children or young adults. The röntgenogram, together with the clinical history and physical signs, is usually sufficient to establish the diagnosis; but in the small group in which it is impossible to make a correct diagnosis, I believe one is justified in performing a biopsy. We have used the aspiration method of biopsy in this type with some success.

Treatment.—Surgery alone has given very poor results: only one case in twenty-two reported by Howard and Crile[20] was alive three years after amputation. I have never seen a case cured by amputation alone.

Some remarkable recoveries under toxins and irradiation combined are reported in my paper on Endothelial Myeloma, already referred to (1931). While a very considerable number of cases have been treated by primary irradiation alone (twenty-five cases in our own series), so far there has been only one five-year cure, but, unfortunately, in this case there was no microscopical examination to verify the diagnosis.

We are able to report but a very few cases treated by amputation after prolonged irradiation for the reason that while one is congratulating himself on the rapid diminution or complete disappearance of the primary tumor, metastases frequently develop, and it is then too late to amputate. We have, however, ten cases in which amputation was performed after prolonged irradiation. This group contains one five-year cure; no patient survived amputation much longer than one year. A review of the earlier statistics of Gross, and of the later statistics of Meyerding and others, shows but few cures from amputation alone in that group previously classified as small round-cell sarcoma but now known as endothelial myeloma or Ewing's sar-

coma. While we have been able to treat successfully a considerable number of cases of endothelial myeloma that were beyond amputation, and in some of which metastases had already developed, we must admit that we have not infrequently failed to control the disease even when the treatment (toxins and irradiation) was begun at an early stage. Thus it is difficult to decide on the best method of procedure in an early operable case of endothelial myeloma of a long bone. If we amputate at once, following this with prolonged prophylactic-toxin treatment, we may expect a permanent cure in about 50 per cent. of the cases. If we try to control the disease by local irradiation combined with systemic toxin treatment, we shall probably get a successful result in at least 30 per cent. of the cases. A certain number,

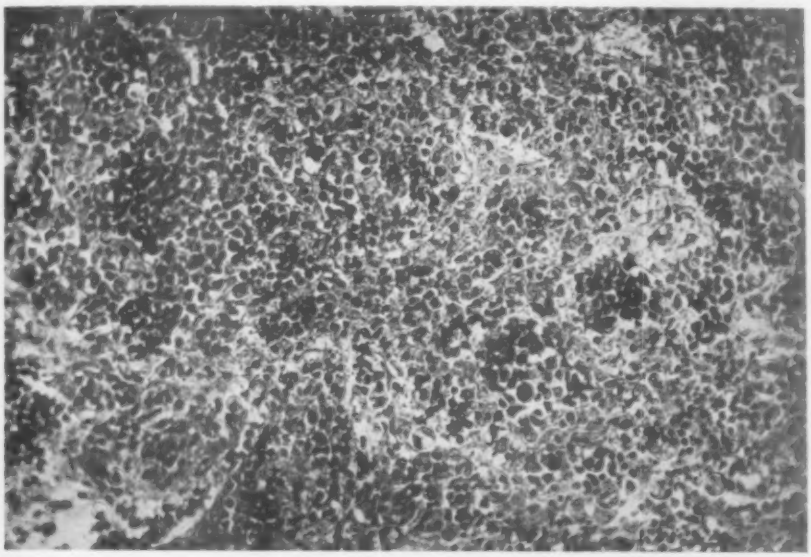

FIG. 3.—Microphotograph.

however, will develop metastases while undergoing treatment and even while the local condition is showing marked improvement; then amputation cannot be considered. In view of the complexity of the question of treatment, it is well when dealing with an adult patient to explain the matter as fully as possible and to let him have some voice in the decision.

A careful analysis of the end-results of different methods of treatment would seem to warrant the conclusion that while endothelial myeloma is the most malignant of all types of bone tumor, one is justified in trying systemic treatment with the toxins of erysipelas and *Bacillus prodigiosus* (Coley) combined with local irradiation, preferably the radium pack, for a limited period before resorting to amputation. If no marked improvement is noticed at the end of six or eight weeks, amputation or resection should be performed, followed by prolonged prophylactic-toxin treatment. Further delay without evidence of improvement may result in the development of metastases, with the loss of all hope of saving the life of the patient.

The most significant fact brought out by our statistics is the comparatively large number of inoperable cases that have recovered and remained well for five years or more. Fifteen cases of inoperable long-bone sarcoma were well more than five years; nine were treated by toxins, and six by toxins and radiation.

Multiple Myeloma.—This type of tumor has long been regarded as uniformly fatal, so much so that but scant reference to the subject of treatment is made in any of the literature. Geschickter and Copeland,[25] in their report of thirteen cases observed at Johns Hopkins, pass over the subject of treatment with the following brief statement:

> With no proved case reported as cured it is evident that palliative symptomatic treatment only is available. Nursing care to avoid unnecessary pain on motion and pathologic fracture is important. When fractures occur, the ordinary methods of treatment by fixation may be given, as pain is thus minimized and healing often accomplished. Morphine for pain, liver diet and tonics for anæmia and inhalations for respiratory complications are helpful.

According to Ewing,[27] these cases invariably have a fatal termination. Meyerding[26] believes treatment is of little avail. He states: "Radiotherapy may produce temporary benefit; surgical treatment is of no value except as a diagnostic aid, and transfusions are of transient value."

In a recent paper on the subject, covering fifteen cases of multiple myeloma, I reported a case in which the disease involved the spine and ribs; there was partial paraplegia; the diagnosis had been confirmed by microscopical examination. Under Coley's toxins alone this patient made a complete recovery and remained well for five years, when he died of lobar pneumonia. In another case in which the disease involved the spine and ribs and was accompanied by complete paraplegia and loss of fifty pounds in weight, and in which irradiation had been tried without success, the patient made a good recovery under Coley's toxins. One year later, he was able to walk about with the aid of a cane, he had regained most of his lost weight, and röntgenograms of the skeletal bones showed no evidence of the disease. He was still in good health when traced, more than three years after the beginning of treatment; but I have learned recently that he has a recurrence.

Inasmuch as these tumors are radiosensitive and as most of the bones are involved, the Heublein unit established at the Memorial Hospital a year ago would seem to be the best method of administering the treatment. By this method the patient receives continuous irradiation all day, with the exception of short intervals for meals and medical visits, over a period of many days or until the desired erythemic dose has been received, depending on the indications in a given case. The usual period is from two to three weeks. One patient with multiple myeloma was treated in the Heublein unit of the Memorial Hospital about six months ago with very marked improvement. The Heublein method of irradiation, combined with systemic treatment with Coley's[28] toxins, seems far superior to any other for such a temporary condition.

In view of the results obtained in our series, I have come to the conclusion that the prognosis in multiple myeloma is by no means as hopeless as is universally believed. In a number of cases the disease has been held in check for a considerable period of time by Coley's toxins alone and by irradiation alone; it is apparently susceptible to both agents; therefore I believe a combination of systemic toxins and local irradiation is the method of choice in the treatment of multiple myeloma; and no case should be given up as hopeless until this combined treatment has been given a thorough trial.

Giant-cell Tumors.—Curiously enough, there still remain the same doubt and uncertainty that existed seventy years ago, as to the true nature of the so-called benign giant-cell tumor. The theory that these tumors are always benign and never metastasize dates back to the first half of the nineteenth century (Lebert,[31] Paget[30] and Nélaton[32]). Virchow[33] (1862), however, contended that giant-cell tumors are sometimes malignant and give rise to metastases, and his opinion was strongly endorsed by Gross,[34] (1874). Some twenty-two years ago the whole question was revived by Bloodgood,[35] and it was largely due to his somewhat dogmatic and frequently reiterated statement that giant-cell tumors are always benign and never metastasize, that surgeons were led to abandon amputation as the primary method of treating giant-cell tumors, and to attempt to save the limb by curettage or irradiation. Irrespective of whether we agree with Bloodgood's views or not, we *must* admit that his teachings have had an important influence towards a more conservative treatment of these tumors, and that many limbs have been saved thereby. The view of the benignity of giant-cell tumors gradually gained adherents, and by 1924 it might be stated that the majority of pathologists all over the world had adopted it. In my[36] paper on the Prognosis in Giant-cell Sarcoma of the Long Bones, based on a study of fifty cases personally observed, I stated:

> There is only one explanation of these cases which still leaves it possible for one to entertain the theory that giant-cell tumors are always benign; and that is to assume that all of the cases here reported, in which metastases developed ending in death, were cases of mistaken diagnosis. As a matter of fact, however, in the author's personal series of cases, the diagnosis of benign giant-cell sarcoma was made not only by competent pathologists, but in many cases by the very pathologists who had made a most careful study of bone tumors; so that if men of such wide experience are unable to differentiate the benign from the malignant type until death from metastases occurs, how much less likely is it that pathologists of ordinary experience will be able to make such differentiation.

Since the publication of that paper I have had an opportunity of studying forty-eight additional cases, making a total of ninety-eight cases of giant-cell tumor of the long bones observed at the Memorial Hospital and the Hospital for Ruptured and Crippled. In no less than fourteen cases the condition proved to be malignant; in four of these cases the early diagnosis of giant-cell sarcoma rested on clinical and röntgenological evidence alone; later, after prolonged irradiation, the diagnosis was confirmed by microscopical examination.

FIG. 5.

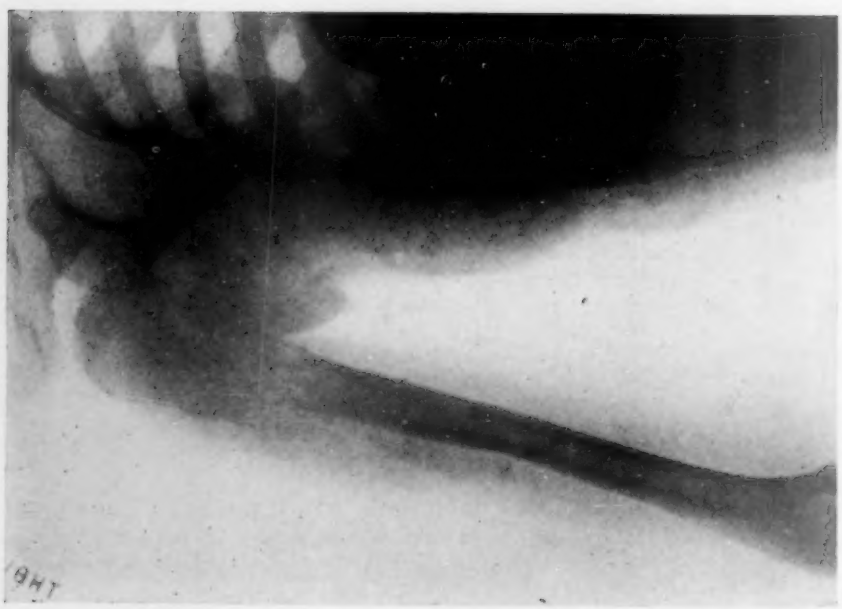

FIG. 4.

FIG. 4.—May, 1923. Giant-cell sarcoma of humerus. Toxins and radiation after exploratory operation. Patient well nine years later. Bone Sarcoma Registry at first classified this case as a malignant osteogenic sarcoma; later revised diagnosis.
FIG. 5.—Same case six months later.

A number of other surgeons have published cases of giant-cell tumor associated with metastases: Behring[37] collected 384 cases of sarcoma of the long bones operated upon in the leading hospitals of Sweden during the years 1901 to 1926. The diagnosis was verified histologically in all but two cases of a series of 246. Of this group, twenty-seven were classified as giant-cell sarcoma. All were operated upon more or less radically. In all of these cases the diagnosis of giant-cell sarcoma was made histologically by pathologists of large experience in the study of bone tumors. However, no less than

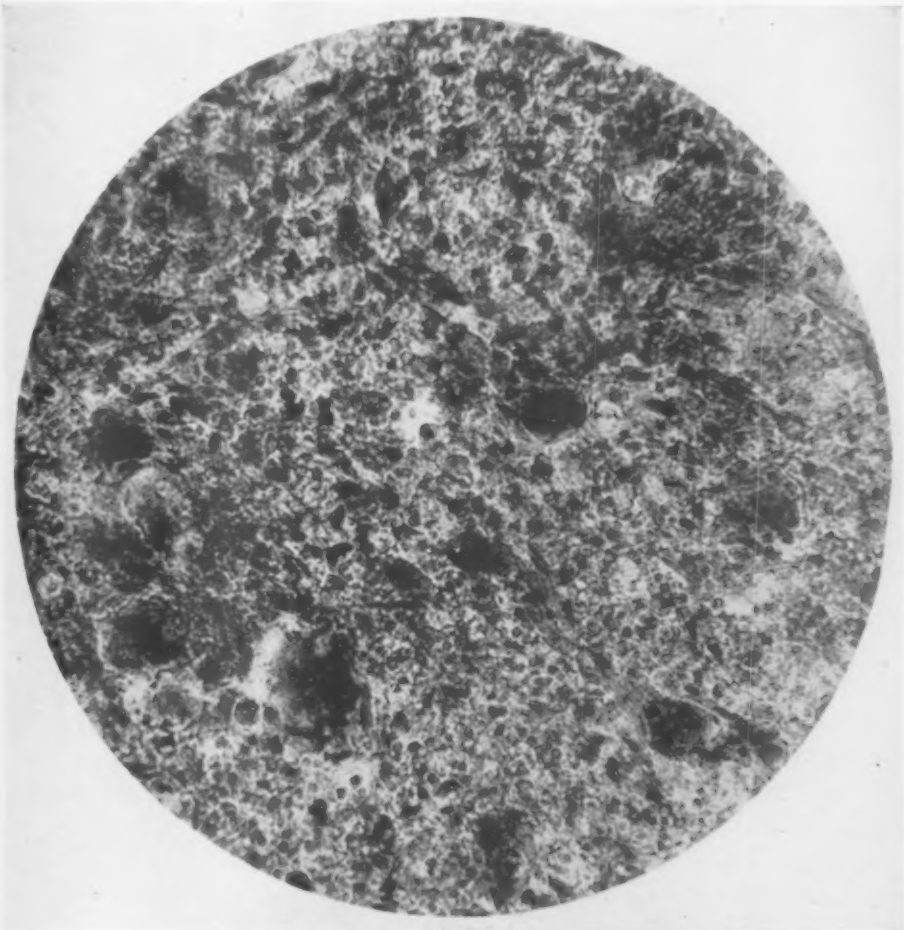

FIG. 6.—Microphotograph of same case as FIG. 4.

six of the twenty-seven patients died of metastases. Behring feels that the question of whether giant-cell tumors are always benign must be left open for the present.

Korchow,[38] of the State Institute of Radiology and Cancer Research, Leningrad, has made a study of fifteen cases of giant-cell tumors of bones observed during one year. It is interesting to note that in eleven cases trauma seemed to be an important etiological fact. While thirteen cases ran a benign course, two proved malignant. Eleven were treated by X-rays and four by operation. One was cured, two improved, nine unaffected, two became worse, and one died (but not as a result of the tumor). The author concludes that these tumors start as osteitis fibrosa but owing to trauma and other unfavorable factors the osteitis develops into a tumor which may become malignant. He

advocates biopsy for diagnosis and treatment. In most cases he believes that surgical treatment should be conservative (curettage, resection). According to Korchow, irradiation does not give very satisfactory results and is only specially indicated when operation is difficult or impracticable on account of the site of the tumor.

Simmons[28] states, in his review of the giant-cell tumors of bone collected by the Bone Sarcoma Registry prior to 1925 (116 in number), that he has seen four cases of giant-cell tumor in which death occurred from metastases; two were registered prior to 1925 and two since that date. Simmons adds that he knows of several other unpublished cases observed at other clinics, and that Codman also has seen several other cases.

These statistics and others would seem to force one to the conclusion that while the majority of giant-cell tumors are benign or only locally malignant, there is a very definite number which, while clinically and microscopically benign in the earlier stages, do later take on malignant characteristics and cause death by metastases. These cases, I believe, furnish conclusive proof that the view held by Virchow and Gross is more nearly correct than that of Nélaton. This does not mean that we as practical surgeons should move the clock backwards and again treat giant-cell tumors of the long bones by amputation as formerly. Experience has taught us that amputation as a primary method of treatment should seldom, if ever, be employed. Practically all these cases should be treated by conservative measures. I have not performed a primary amputation for a benign giant-cell tumor of a long bone for thirty years.

Treatment of Giant-cell Tumors.—The main objections to the surgical treatment of giant-cell tumors have been especially emphasized by Ewing and Herendeen. They are: First, the danger of serious hæmorrhages in the larger and more vascular giant-cell tumors; and second, the danger of infection either at the time of operation or later, due to failure to obtain primary union of the biopsy wound. It is asserted that if the larger cavities are packed with gauze they are apt to become infected sooner or later, while if an unhealed sinus persists, re-infection may occur, and amputation may become necessary.

Such is the picture often drawn illustrating the dangers of surgical treatment. There is no doubt that these dangers do exist and have been associated with the surgical treatment of giant-cell tumors in the past. The matter of chief practical importance is: are they seen frequently or but rarely, and are they associated with some failure in surgical technic? The critics of this treatment apparently think they are very common sequelæ. As a matter of fact, however, if curettage is performed with sufficient care and thoroughness, no packing is necessary; the wound can be entirely closed, and in nearly every case it will heal by primary union.

A careful analysis of more than 200 cases treated surgically at Johns Hopkins (100 by curettage) gives no support to the theory that infections with their attendant dangers are of frequent occurrence. In the entire series they were extremely rare and there were no deaths.

On the other hand, the bad results of irradiation in the treatment of giant-cell tumors are almost never mentioned, and from a study of the literature one might infer that they never occur. If we analyze the cases treated by this method at the Memorial Hospital, we find a considerable number of bad results that are quite as serious, if not more so, than those connected

with surgical treatment. Among them may be mentioned that of pathological fracture. This not infrequently follows prolonged irradiation, especially in sarcoma of the femur. Of twenty cases of giant-cell tumor of the femur treated by irradiation at the Memorial Hospital, six developed a pathological fracture.

Then there is the danger of a late osteomyelitis developing after an apparent cure by irradiation. This has been observed in two cases under my own obsevration; in both an amputation was necessary. In addition there is the risk of radium burns which still occur occasionally even in the hands of experienced radiologists.

My chief objection to regarding irradiation as the method of choice in

FIG. 7.

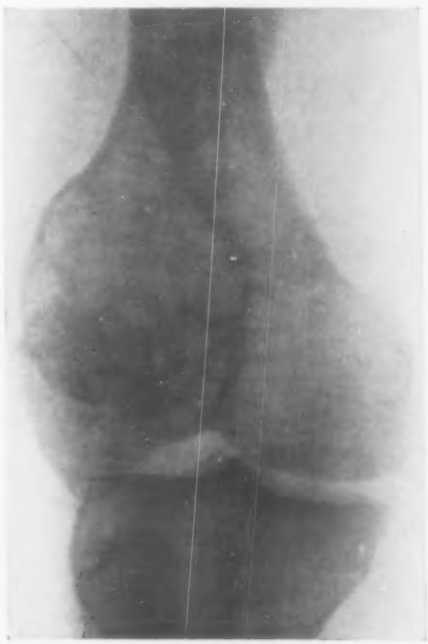

FIG. 8.

FIG. 7.—Giant-cell medullary sarcoma of lower end of femur, knee-joint, and upper end of tibia. Treated with toxins and radium. Limb saved. Patient well eight years later when she died of hæmorrhages from childbirth.
FIG. 8.—Same case as FIG. 7, showing how Nature has reformed the destroyed condyle. Five years after treatment.

the treatment of giant-cell tumors of the long bones are: (1) The long period of disability, and (2) the impossibility of making a correct diagnosis of benign giant-cell tumor in at least one out of five cases from the clinical and röntgenological evidence alone.

Another advocate of irradiation for giant-cell tumors is Regaud,[40] but a glance at his statistics shows that of the fourteen cases reported, twelve occurred in the jaw (in these he had nearly 100 per cent. recoveries); one in the cervical spine, and only one in a long bone. This, unfortunately, was

treated primarily by resection and later by irradiation for a recurrence, so that Regaud's statistics offer practically no evidence of the value of irradiation in the treatment of giant-cell tumors of the long bones.

The prognosis in this group of tumors has been found to vary greatly with the particular bone affected, being graver when the disease is located in the lower end of the femur and the upper end of the tibia than when the radius, ulna or fibula is involved.

While our results at the Memorial Hospital have proven beyond a doubt that it is possible to cure a giant-cell tumor of a long bone, even of the femur or tibia, by irradiation, I do not think we have as yet proven this method to be superior to all others. There is still a grave objection to treating a supposed giant-cell tumor of a long bone by primary irradiation without a biopsy —as advocated by Ewing and Herendeen—for the reason that in at least one out of five cases it is impossible to make a correct diagnosis of benign giant-cell tumor from the clinical and röntgenological evidence alone. In other words, if we proceed in this manner we shall find that one out of every five cases will prove to be a malignant osteogenic sarcoma. By the time the error in diagnosis is discovered it is usually too late to save the life of the patient by amputation. Furthermore, the period of time required for this treatment in the majority of cases is too long to justify a general adoption of the method.

A simple biopsy should never be performed in a case of giant-cell tumor or one in which the clinical and röntgenological evidence points strongly towards a giant-cell tumor. If a giant-cell tumor, particularly of the long bones, is cut into at all, a thorough curettage down to healthy bone should be performed, the wound swabbed out with chloride of zinc or carbolic acid, and, if possible, closed without drainage. If this is done, then we have not performed a biopsy but have employed the surgical treatment, which, in my opinion, is the method of choice for giant-cell tumors. A simple biopsy is not advocated because of the difficulty of obtaining primary wound-healing, and the danger of sinus formation and infection owing to the high vascularity of these tumors.

During the last two years at the Memorial Hospital, in many cases of giant-cell tumor in which the bony shell* has been penetrated, we have found it possible to make an accurate diagnosis by the aspiration biopsy of Martin and Ellis[41] or[42] the Hoffman-punch biopsy. If a diagnosis can be made by the aspiration method without an incision, then my principal objection to the use of primary irradiation in the treatment of giant-cell tumors will have been overcome.

In many cases, however, it has been found necessary to introduce a large needle into a number of areas; and it is quite conceivable that in a highly vascular tumor some of the cells set free by the aspiration might enter the

*If the bony shell has not been destroyed it is impossible to use the aspiration biopsy method.

FIG. 9.

FIG. 10.

FIG. 9.—Giant- and spindle-cell sarcoma of femur with extensive involvement of entire knee-joint. Exploratory incision; toxins. Patient well fourteen years later. Picture shows Nature's attempt to form new condyle.
FIG. 10.—Another view of same case as FIG. 9.

circulation and be carried to other parts of the body, thus giving rise to metastases. I am not at all sure but that this risk might be as great if not greater than any associated with a biopsy of the ordinary type. In one case, a large, highly vascular tumor of the ilium, the patient died suddenly of embolism on the day after an aspiration biopsy. It is possible that it was in no way connected with the biopsy.

If, on the other hand, the case is treated primarily by surgery combined with toxins or toxins and irradiation, the entire tumor will have been removed by curettage and the surgeon will have the benefit not only of a clinical, röntgenological and macroscopical examination, but of a careful histological examination as well. If the tumor proves to be a malignant central sarcoma,

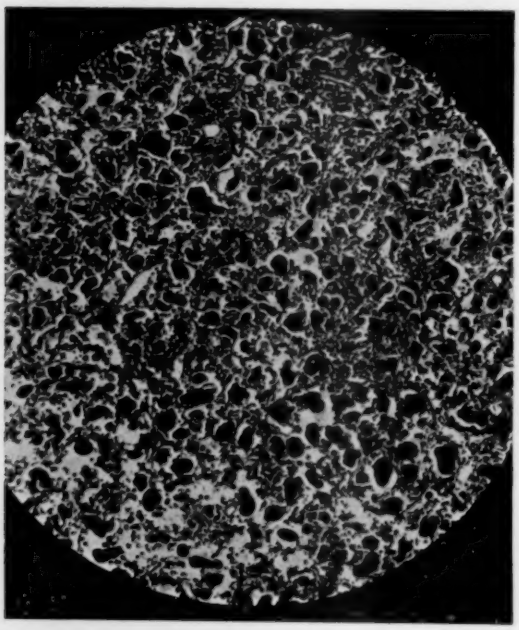

FIG. 11.

FIG. 12.

FIG. 11.—Malignant giant-cell sarcoma of mid-dorsal region. Microscopical diagnosis: round-cell sarcoma with many atypical giant cells. (Dr. Harlow Brooks.) Complete paralysis of bladder, rectum and lower extremities. Under four months' toxin treatment, patient made a complete recovery and is well thirty years later.

FIG. 12.—Giant- and spindle-cell sarcoma of tibia with destruction of upper four inches, treated by curettage, toxins and radium. Limb saved; patient well eighteen years later. Picture shows replacement of new bone five years later. Well seventeen years later.

immediate amputation should be performed followed by a course of prophylactic-toxin treatment. This method offers a much greater chance of saving the life of the patient. If the tumor proves to be a benign giant-cell sarcoma, the curettage and toxin treatment will, in my opinion, effect a complete recovery in the great majority of cases and in a shorter period of time than is required by irradiation.

Summary of Results.—In view of Bloodgood's repeated statement that the Johns Hopkins series prior to 1913 contains no case of bone sarcoma that has remained well for a period of five years, following any method of

treatment, I should like to call attention to the fact that our earlier series treated prior to 1913 contains nineteen cases of bone sarcoma of verified diagnosis that have remained well for from five to thirty-eight years. Nine of these cases were classified as endothelioma or small round-cell sarcoma, and ten as osteogenic sarcoma.

To this group we might add one other case of malignant giant-cell tumor of the spine associated with complete paraplegia and loss of fifty pounds in weight, treated in 1902 with Coley's toxins alone. (Fig. 13.) This patient was in excellent health with perfect function when I last examined him in July, 1932, thirty years after treatment.

In my[43] paper of 1913 I gave a tabulated report of 125 cases of sarcoma successfully treated with the toxins by other men. In this group were thirty cases of bone sarcoma that had remained well for five years or more; sixteen were inoperable sarcomas of the flat bones (diagnosis confirmed microscopically in eleven cases) and fourteen sarcomas of the long bones: six osteogenic sarcoma, five endothelioma, one giant-cell tumor, and no microscopical examination in two cases.

Results in 168 Cases of Primary Operable Osteogenic Sarcoma of the Long Bones Treated by Irradiation

Method	Cases
Röntgen-ray	84
Röntgen-ray and radium	10
Radium (element pack in 30 cases)	35
Irradiation and Coley's toxins	39
	168

Of the eighty-four cases treated by röntgen-ray, the only five-year cures occurred in two cases in which amputation was performed after irradiation, and in one case treated by resection followed by irradiation.

Of the ten cases treated by röntgen-ray and radium, five-year cures occurred in two cases in which amputation was performed after irradiation.

Of the thirty-five cases treated by radium alone, the only five-year cure occurred in one case in which amputation was performed after irradiation, and in one case treated by resection and irradiation.

In other words, of 129 cases of osteogenic sarcoma treated by irradiation, there were no five-year cures obtained without amputation or resection. The percentage five-year cures in this group was 5.42 or seven cases.

Of the thirty-nine cases treated by irradiation and Coley's toxins, there were two five-year cures obtained without amputation, and two with amputation. Three other cases in which the limb was saved have remained well from two to four and one-half years. One of the five-year cures without amputation was a very extensive tumor of the humerus treated with irradiation and toxins over a period of one year. While the Bone Sarcoma Registry committee at first classified it as an osteogenic sarcoma, five years later they revised their diagnosis to that of giant-cell tumor. Excluding this case we have three five-year cures in a group of thirty-nine cases (7.9 per cent.).

Of the total number of 168 cases of operable osteogenic sarcoma of the long bones treated by primary irradiation, nine, or 6.4 per cent., were well for five years or more.*

While the results obtained by irradiation and Coley's toxins (7.9 per cent. five-year cures) are a little better than those obtained by irradiation without toxins (5.42 per cent. five-year cures) they are no better if as good as the results obtained by early amputation alone without pre-operative irradiation. This proves that osteogenic sarcoma is highly resistant to both irradiation and toxins and that we are no longer justified in substituting either for early amputation. The only two cases in the entire series of 168 operable osteogenic sarcoma in which the limb was saved were two in which the toxins were used in conjunction with irradiation.

Results in 72 Cases of Endothelial Myeloma of the Long Bones

Treatment	Cases	Five-year Recoveries
Amputation alone	2	0, or 0 per cent.
Coley's toxins	9	6, or 66.66 per cent.
Coley's toxins plus amputation or resection	14	9, or 64.3 per cent.
Irradiation	25	1, or 4 per cent.
Toxins and irradiation	22	6, or 27.27 per cent.
Totals	72	22, or 30.55 per cent.

NOTE.—Of forty-five cases in which the toxins were used either alone or in conjunction with surgery or irradiation, twenty-one, or 46.6 per cent., have remained well for five years.

Results in 217 Cases of Malignant Tumor of the Long Bones in which Amputation Was Employed

Treatment	Cases	Five-year Recoveries
Amputation alone	15	0
Amputation and Coley's toxins	81	24, or 29.6 per cent.
Amputation after prolonged irradiation without toxins	98	5, or 5.1 per cent.
Amputation after prolonged irradiation with Coley's toxins	23	2, or 8.7 per cent.

Of the latter two five-year recoveries, one was a periosteal fibrosarcoma of the tibia.

Femur Cases.—In making a comparative study of early and late statistics, it will be found that the most notable improvement in results are in sarcoma of the femur. While Butlin was able to find only one three-year recovery in a group of sixty-eight cases of sarcoma of the femur treated by disarticulation or amputation below the trochanter, our series of over 100 cases of sarcoma of the femur shows twenty-one five-year recoveries (twelve osteogenic and eleven endothelial myeloma). Of the eleven endothelial myelomas, no less than seven were inoperable and three had extensive metastases at the beginning of treatment; the limb was saved in seven cases. The treatment employed in these cases was as follows:

* In 10 of these cases the X-ray treatment had been carried out at other hospitals before the patients came under my observation.

	Five-year Recoveries	Per Cent.
Amputation alone in 10 cases	0	0
Amputation followed by Coley's toxins in 42 cases	12	28.57
Amputation after prolonged irradiation in 48 cases	3	6.3
Toxins and irradiation	3	
Toxins alone	3	
Total	21	

As to giant-cell tumors of the femur, our results at the Memorial Hospital would seem to lend some support to the view of Phemister (quoted by Pfahler) that these cases should not be treated primarily by irradiation. We have seventeen cases of giant-cell tumor of the femur that were treated by primary irradiation; nine went on to amputation, and four died. Two other cases, after amputation, proved to be malignant osteogenic sarcomas, but these are too recent to mention the end-result.

Results in 98 Cases of Giant-cell Tumor of the Long Bones

	Cases
Treated by Coley's toxins, with or without surgery	21
Proved to be malignant osteogenic sarcoma	2
Primary amputation (one by another surgeon)	2
Secondary amputation	5
Well five years or more	12
Dead (osteogenic sarcoma)	2
Treated by toxins and irradiation	16
Proved to be malignant osteogenic sarcoma	2
Amputation	9
Well five years or more	9
Dead	2
Treated by irradiation without biopsy or operation	31
Proved to be malignant osteogenic sarcoma	6
Amputation	8
Well five years or more	11
Dead	5
Died of another cause	1
Treated by irradiation after biopsy or curettage	17
Proved to be malignant osteogenic sarcoma	2
Later amputation	7
Well five years or more	6
Dead	4
Treated by surgery alone	13
Proved to be malignant osteogenic sarcoma	2
Primary amputation (two by other men)	4
Resection	3
Secondary amputation	3
Well five years or more	2
Dead	2

It should be noted that in the thirty-one cases of benign giant-cell tumor treated by irradiation without a biopsy, six proved to be malignant osteogenic

sarcoma; all dead. In the entire group of ninety-eight cases there were fifteen deaths.

Five-year Recoveries.—Of a total of 261 cases of malignant sarcoma of the long bones, exclusive of giant-cell tumors, treated prior to November, 1927, or five years ago, fifty-four, or 20.7 per cent. have remained well for five years or more. Twenty-two were classified as endothelial myeloma, and twenty-two as osteogenic sarcoma. Coley's toxins were used in forty-four of these five-year recoveries. Fifteen cases were either inoperable when the treatment was begun or became inoperable during the course of treatment.

Limb saved.—Of these fifty-four five-year recoveries, the limb was saved in twenty-one cases (twelve endothelial myeloma and nine osteogenic sarcoma). In all but two cases the diagnosis was confirmed by microscopical examination, but in these two there was a rapidly growing, extensive tumor of the femur involving the upper half of the shaft, beyond hip-joint amputation. One patient recovered under toxins alone and was well ten years later when last traced, and the other had toxins and one radium-pack treatment, and is well fifteen and one-half years later.

Conclusions.—I believe that a study of the results obtained in this series of 360 cases of malignant operable sarcoma (exclusive of 98 giant-cell tumors and nearly 100 inoperable cases) will prove that the present pessimistic attitude regarding the prognosis is without foundation in fact. The prognosis depends largely upon an early diagnosis and a wise choice of treatment.

For osteogenic sarcoma, especially the type associated with marked new bone formation, I advise immediate amputation as soon as the diagnosis has been established. In order to lessen the chances of a recurrence, Coley's toxins should be given as a prophylactic, for a period of six months.

While endothelial myeloma is highly sensitive to both toxins and irradiation, rarely has the disease been controlled by irradiation alone. On the other hand, the toxins alone or toxins combined with irradiation have resulted in a large number of five-year recoveries even, in some instances, after the disease had reached the inoperable stage and had developed metastases. I believe that a combination of the systemic effect of Coley's toxins plus the local effect of irradiation offers the greatest hope of saving the patient's life as well as his limb in this type of tumor. Early amputation followed by prolonged toxin treatment would undoubtedly give a higher percentage of five-year recoveries, and for this reason it is well to let the patient have a voice in the final decision as to the method to be employed.

I still believe that the most efficient method of treating giant-cell tumors of the long bones is: Early and thorough curettage, swabbing out the cavity with 50 per cent. chloride of zinc or carbolic acid and alcohol, closing the wound without drainage, and then on the third or fourth post-operative day starting a short course (four weeks) of prophylactic-toxin treatment to be given in moderate doses. Primary amputation or resection should practically never be performed in this type of tumor. Our series contains many cases

in which large areas of bone-destruction were completely restored by Nature, showing that resection and bone-grafting are unnecessary.

The series of cases reported in this paper differs from all others in two important points: (1) It includes a large number of inoperable, hopeless cases that have recovered under treatment and have remained well for more than five years, and (2) it contains a large number (19) of permanent recoveries that have taken place prior to 1913. The only possible explanation of these results is, that in the majority of cases Coley's toxins either alone or in conjunction with some other method were used.

In closing I wish to express my great appreciation to the following: to Dr. James Ewing and Dr. Frederick W. Stewart, for their kindness in examining most of the microscopical sections in this series of cases; to Dr. Ralph Herendeen and Dr. James J. Duffy, for their skilful treatment of the cases in which irradiation was employed; and to Dr. Bradley L. Coley, who has been associated with me for the past ten years in the Department of Bone Sarcoma at the Memorial Hospital and the Hospital for Ruptured and Crippled and who has performed the majority of amputations during this period.

Bone sarcoma is a field in which a careful weighing of all evidence, the clinical, the röntgenological and the histological, is required. In other words, in order to arrive at a correct diagnosis, especially in the early stages of the disease, a close coöperation on the part of the surgeon, the röntgenologist and the pathologist is most essential.

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TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

STATED MEETING HELD MAY 2, 1932

The President Dr. John Speese, in the Chair

Calvin M. Smyth, Jr., M.D., Recorder

LUMBAR SYMPATHECTOMY IN BUERGER'S DISEASE

Dr. Frederick A. Bothe presented a man, thirty-one years of age, who was admitted to the Presbyterian Hospital November 2, 1926, in the service of Dr. John Speese, on account of pain in both feet. He first experienced pain in the feet three months prior to admission. It was burning in character and he expressed it as feeling like "hot coals"; it was followed by a blanching of the skin and later the appearance of a purplish-red color, more pronounced in the toes. The pain would last from two to thirty minutes and then subside. These symptoms gradually became more severe and the week before admission to the hospital he suffered almost constantly. The pain was so severe at night that he was unable to sleep. He suffered more with the left than the right foot. Both second toes and the right great toe gave him the most constant severe pain.

Physical examination was essentially negative, except for the lower extremities. Both feet were perceptibly colder than the other parts of the body. When the feet were elevated there was definite blanching of all the toes and to a lesser degree the blanching extended up over the dorsum of both feet. When the legs were subsequently lowered, a deep purplish-red color replaced the blanched areas. All toes of both feet were involved. There was a large purplish spot about the size of the palm of one's hand on the dorsum of the left foot which persisted. A similar change occurred on the right foot but to a lesser degree. The pulsation of the dorsalis pedis artery was not palpable on the left foot and that of the posterior tibial was very faint. On the right foot both the dorsalis pedis and the posterior tibial pulsations could be felt but they were impaired.

A diagnosis of Raynaud's disease was made, and November 3, 1926, a left lumbar ganglionectomy was performed excising from the second to the fourth lumbar ganglion inclusive, and a peri-arterial sympathectomy for a distance of four centimetres was done on the left common iliac artery. Only one side was done at this time, the side which was giving him the most symptoms. Immediately after the operation his left foot felt warm and definite relief was obtained from suffering in this extremity, although it did not entirely disappear. Comparatively speaking, after the first operation he suffered less with his left leg than with his right leg. November 13, 1926, a similar procedure was done on the right side. Two months after the original operation, the second toe on his left foot had to be amputated, because of gangrene which would not clear up following the sympathectomy. One year after operation, the patient was readmitted as the symptoms had become progressively worse in his right foot, and gangrene had developed. The entire foot was a dusky red and cyanotic, and there was a sinus between the great toe and second toe. The second toe was gangrenous and no dorsalis pedis pulsation could be palpated. At this time he had little or no suffering in his left foot. A peri-arterial sympathectomy was performed on the right femoral artery, and at the same time the second toe on the right foot was amputated. The peri-arterial sympathectomy

gave no relief, so the right femoral artery was ligated and cut as advocated by Lewis. This gave no beneficial results. By this time the pain was unbearable and the gangrenous process had begun to involve the dorsum of the foot so the right leg was amputated below the knee.

The pathological report of the blood-vessels of the amputated leg was: first, dorsalis pedis shows proliferation of connective tissue with round-cell infiltration in all coats. The lumen is obliterated by an organizing thrombus. The posterior tibial artery shows the same microscopical findings in the wall and there were necrotic areas in the intima. *Diagnosis.*—Thrombo-angiitis obliterans.

The healing power was poor and reamputation was necessary above the knee before a satisfactory stump could be obtained. Following amputation intravenous injections of typhoid vaccine were started. These were given once a week for six weeks and then omitted for six weeks. This schedule was followed for this form of therapy. Twenty-five million organisms were used in the first injection and this number had to be increased to 200,000,000 before a reaction was obtained. This dosage was employed throughout the remainder of the protein therapy.

At the present time, five and a half years after his operation, he has a little soreness in his left foot which he expressed as being negligible. There is no blanching of the skin of the foot or toes when the foot is elevated and the purplish-red discoloration does not appear when the foot is lowered.

Dr. Francis C. Grant said that at the University Hospital, there had been eight cases of Buerger's disease under his care. The results had been satisfactory with lumbar sympathectomy in all of them. One case was that of a thirty-five-year-old colored man who had a gangrene of the great toe of the right foot, with intense pain. The gangrene was sharply demarcated about the base of the toe. There were no arterial pulsations to be felt in either of the arteries of the foot. The femoral artery could be palpated but the popliteal could not. There was no sign of sugar in the urine and no evidence of arteriosclerosis. Blood sugar was normal. A right lumbar sympathectomy was done and his toe was amputated at the same time. At the time of the amputation, there was no bleeding and the chances for healing of the wound seemed to be very poor. He was kept in bed for six weeks, with the foot elevated and light treatment given over the wound. At the end of that time definite granulation tissue was appearing although a mild infection hampered repair. At the end of three months, the foot was entirely healed. The pain was relieved promptly following operation and has never returned. At the present time, two years following operation, the patient has had perfect healing without further trouble and no pain, and is able to be about wearing the shoes to which he is normally accustomed.

In cases of this type, where hitherto amputation would have been done, it seems justifiable to try the effects of lumbar sympathectomy first. By this procedure a number of limbs may be preserved.

Dr. George P. Muller remarked that he had twice exposed the lumbar sympathetics by an extraperitoneal approach. Beginning as a muscle-splitting (McBurney) exposure the peritoneum is swept off the fascia and muscles, past the ureter to the great vessels. It is quite simple to do in a thin person.

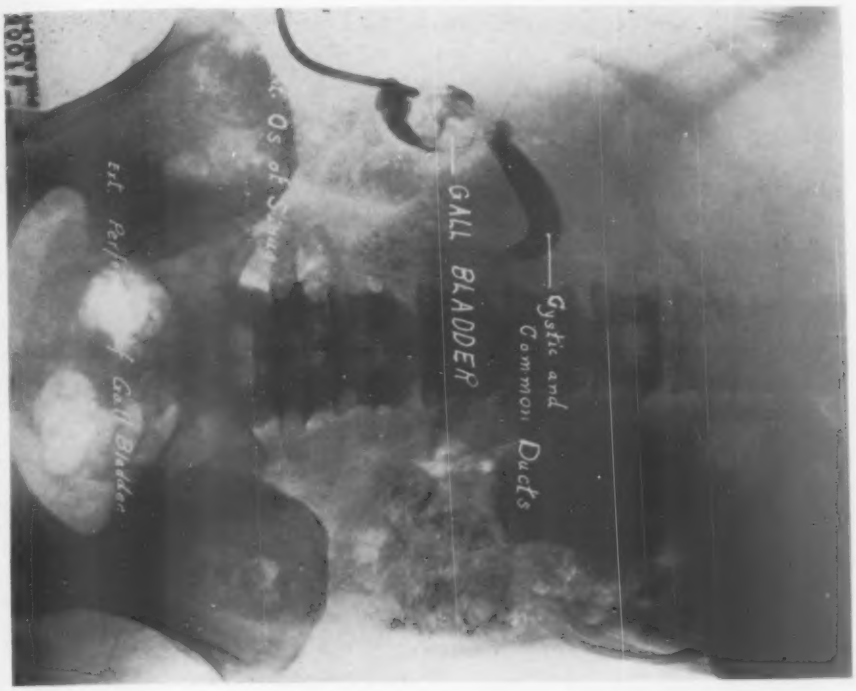

FIG. 1.—Film after injection of brominol.

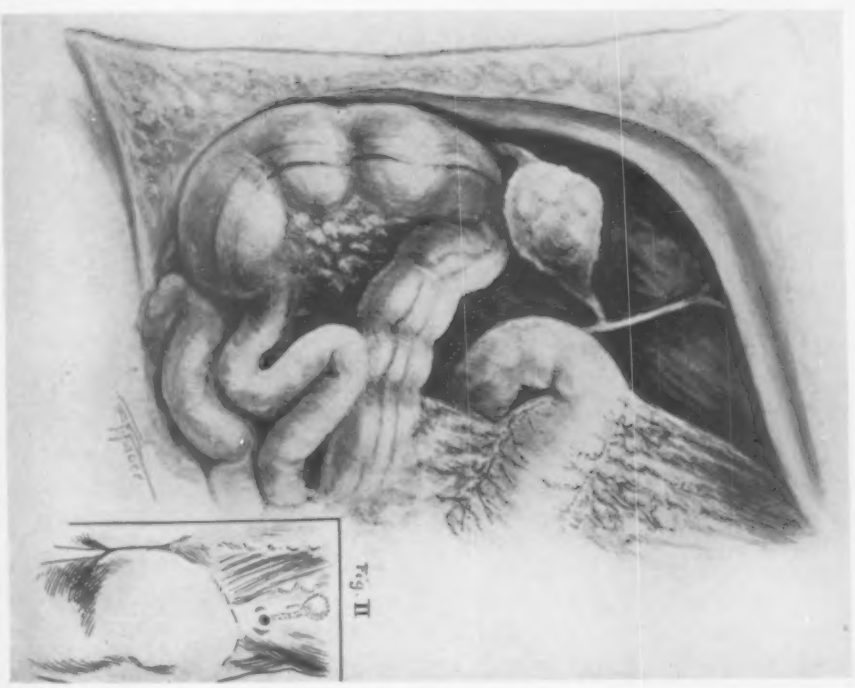

FIG. 2.—Diagram of operative findings. Inset shows location of sinus.

EXTERNAL PERFORATION OF THE GALL-BLADDER

Dr. George P. Muller reported the case of a white woman, aged forty-five years, who was admitted to Service B of the University of Pennsylvania Hospital October 25, 1931, complaining of a draining sinus in the right flank.

Eleven years before admission she began to suffer from attacks of upper right quadrant pain. These attacks were severe, the onset usually sudden, duration variable, and the pain radiated to the back. The attacks were always associated with nausea, vomiting and constipation. There was no history of jaundice, pruritus, or clay-colored stools. The attacks became progressively more severe. In December of 1923 she was admitted to Lankenau Hospital, Philadelphia, during an attack which had existed for two weeks. The pain in this latter attack was atypical; it was lower than usual and more to the right.

Physical examination at that time revealed a smooth mass extending well to the lateral side of the right abdomen, down to the iliac spine, and lateral to the gall-bladder area. The mass did not move with respiration and was not tender. Blood sugar and urea were normal, urinalyses negative and blood count as follows: hæmoglobin, 80 per cent.; red blood-cells, 3,240,000; white blood-cells, 8,400, with normal differential. X-ray of the abdomen (flat plate) showed no evidence of biliary or renal calculi. The right kidney was negative to cystoscopical examination and pyelogram.

At operation, performed by Dr. John B. Deaver, January 4, 1924, a large "growth" was found involving the ascending colon, judged inoperable, and a lateral anastomosis was carried out between the terminal ileum and the transverse colon.

When the patient recovered she was referred to the Oncologic Hospital for radium treatment. Here ten days after admission she developed a large abscess in the right flank. After incision at first only pus exuded, but later the sinus began to discharge small gall-stones. She remained at the Oncologic Hospital six months, receiving three radium treatments over the tumor mass, since this perforation was thought to be due to breaking down of a carcinoma.

From this time on the sinus continued to drain pus and discharge stones, until when admitted to the University Hospital, she exhibited a four-ounce bottle nearly filled with small, facetted, black stones. Local pain occurred with the passage of each stone, followed by relief and improvement in general well-being. Bile never appeared in the drainage.

The patient's status on admission to Service B was essentially the same as described. Her sinus still drained, she had occasional upper right quadrant and epigastric pain, but felt well in general and had been consistently gaining in weight.

A barium enema showed a functioning ileocolostomy, and a suspicious area about three inches distal to the hepatic flexure, although there was no evidence of obstruction.

A cholecystogram was done, and when the gall-bladder showed no shadow in the first film, twenty cubic centimetres of bromidized oil were injected into the sinus. This was observed to pass around a large object, on beyond and into the duodenum. The film (Fig. 1) taken immediately thereafter showed the true state of affairs—namely, a gall-bladder located far more laterally and lower than normal, its cystic duct going upward beneath the common duct to open into it near the duodenum. Defects in the gall-bladder to which the sinus directly led suggested the presence of stone. The cystic duct was plainly visible as a corrugated shadow in the lumen of the larger common duct.

Operation was performed October 31, 1931, under gas and ether anæsthesia. A catheter was first inserted into the sinus, methylene blue was injected, and the catheter left in place. A vertical incision was then made medial to the scar of the previous operation. Adhesions were resected. The ileocolostomy was found to be in good order. A mass was found underneath the liver (Fig. 2), extending against and adherent to the lateral abdominal wall just above the hepatic flexure of the colon. Methylene blue shining through showed this mass to be connected with the sinus. It was dissected

free from the liver above and the colon below. It contained one large gall-stone and several small stones. The gall-bladder was removed with the exception of a small piece of the neck which could not be dissected free. This portion was closed. The fundus of the gall-bladder was found connected with the sinus, and after removal of two stones in this portion, the catheter previously inserted was identified. The wound was then closed with two drains, repairing the incisional hernia by application of fascia.

The patient reacted well to the operation. There was considerable drainage through the old sinus. The anterior drains were removed, and the wound healed normally. The small catheter was kept in the sinus for four weeks, during which time three more stones were discharged. At present the sinus has been healed for three months. Pathological section showed the tissue removed to be gall-bladder surrounded by inflammatory tissue.

External perforation of the gall-bladder is very rare. Gariepsy, in 1929, reviewed

FIG. 3.—Urogenical cyst, gross appearance. (Lee.)

the literature and found only three recorded cases in modern literature. He reported one case of rupture through the anterior abdominal wall, and cited Hoerhammer's case which did the same. Beye reported a case of rupture through the right flank, similar to the present case, and Abell reported another with rupture below Poupart's ligament. Courvoisier, in 1890, reported 196 cases of external perforation, but was himself doubtful of the veracity of the records. Since Gariepsy's report McCay has discussed another case in which perforation occurred through the left lumbar region. He also made use of injection of iodized oil to make his diagnosis. He was unable to find a record of a single similar case.

UROGENITAL CYST OF THE MESOSIGMOID

DR. WALTER E. LEE reported the case of an adult Negro female, forty-seven years of age, who was admitted December 7, 1931, to the B surgical service of the Pennsylvania Hospital, complaining of a dull aching sensation in her lower left abdominal quadrant. She stated that she had been perfectly well until November, 1931. At this time she noticed, when standing for long periods of time, a dull aching pain in her

lower left quadrant. This would frequently be relieved by assuming the lying or sitting position. During the previous two months she was more constipated and would often resort to laxatives. While her appetite had always been good she now frequently eructated large amounts of gas. Within four weeks the pain became so severe that she sought admission to the hospital. The only other positive symptomatology was nocturia three or four times nightly. This was not accompanied by urgency nor burning. She had noticed this especially during the previous three months. At no time had she complained of any severe, sudden, or sharp abdominal pain. Nor had she at any time had any nausea or vomiting.

She was a well-nourished sthenic Negress, in no apparent distress. The physical examination was essentially negative except for the abdomen in which cavity there was a palpable mass the size of an orange in the left lower quadrant, not attached to the skin and quite readily movable. There was slight tenderness on deep pressure but no rigidity. Neither liver nor spleen was palpable.

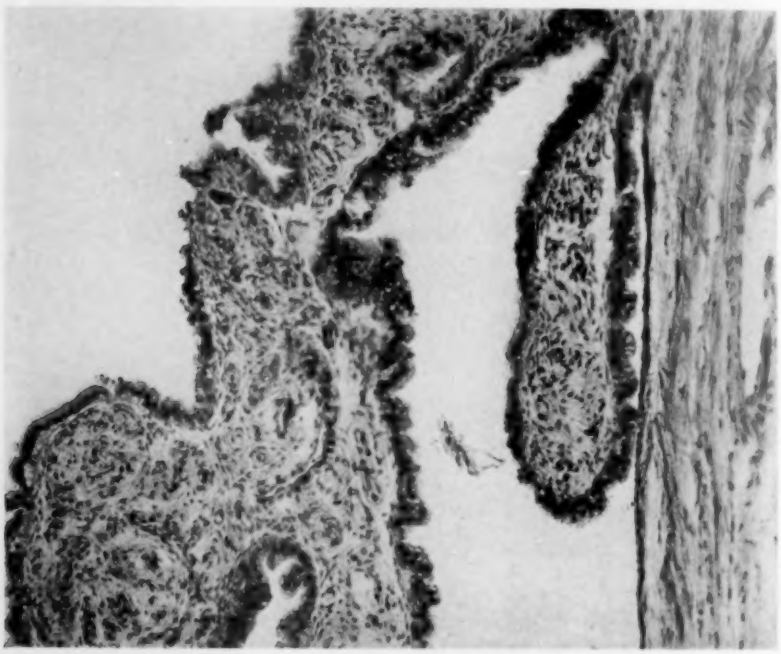

FIG. 4.—Urogenical cyst, microscopical appearance. (Lee.)

A second mass could be felt by bi-manual examination, in the left lower quadrant, indefinite in outline. The adnexa were not palpable.

At operation, December 22, 1931, by Doctor Lee, the omentum was found to be adherent to a mass in the left lower quadrant, after this was dissected free there was observed in the mesocolon, proximal to the sigmoid, a large cystic mass. (Fig. 3.) This mass extended into the pelvis, the lower border being in the hollow of the sacrum. It measured ten by eight by five centimetres. This cystic mass was enucleated without rupturing or injuring the mesenteric vessels, and the mesocolon repaired, no damage having been done to the blood supply. The abdomen was closed without drainage.

The patient's convalescence was uncomplicated and she left the hospital January 14, 1932. She has been seen in the "follow-up" clinic since, and reports being free of symptoms at the present time.

The cyst on being opened showed a thin septum dividing it into two lobules, which contained a clear pseudomucilaginous fluid. Sections taken through the cyst-wall at

various points show microscopically a thin fibrous tissue wall lined with a low, compressed, darkly stained epithelial cell layer. (Fig. 4.) In one place there is a small polyp formation with stroma of connective tissue and epithelial cells resembling those of the Fallopian tube. The pathological diagnosis is a Wolffian duct cyst.

The reporter added to his report of this case the statement that mesenteric cysts, both on account of their rarity and questionable etiology, deserve to be reported. A careful search of the literature shows that three hundred and twenty-nine have been published to date.

It seems most probable that this case may be classified under those of urogenital origin. These form by far the smallest group of peritoneal or mesenteric cysts. Niosi, in 1907, collected five cases. Since that time only twenty-five have been added. The majority of the reported mesenteric cysts have been of the chylous group, and of these the greatest number have been in children. This case is one of the few of the adult cases that have been reported.

Ewing says, when writing of intraperitoneal cysts of urogenital origin: "These cysts are of large size, single, or multilocular, involving mesentery or adjacent regions, or extending into the pelvis, and occur chiefly in adult women. The contents are usually a brownish serous fluid, containing pseudomucin. The wall is composed of fibrous tissue and the lining is of high cylindrical or cuboidal glandular epithelium, which may be deficient in some areas."

The origin of these cysts presents a difficult problem, but it seems probable that they are derived from aberrant remnants of the Wolffian body and that the embryonic disturbance occurs at various periods in the history of this structure.

Incidence.—Most of the reported cases have been in children, although the condition itself may be found at any age. Cases have been reported in fœti and Moynihan[5] reports one in the eightieth year. The incidence in females is greater than in males about two to one.

Pathological Anatomy.—The cysts are usually rounded but may be spherical or lobulated. They vary in size from that of a split pea to one sufficiently large to contain 8.2 litres as reported by Fehleisen.[6] The walls are often very thin, and smooth unless they are adherent to surrounding structures, but cysts have been reported that have had walls as thick as one centimetre.

For the most part mesenteric cysts are located in the vicinity of the terminal ileum and jejunum. Only about 10 per cent. of the reported cases have been located in the mesocolon.

The contents vary in color, consistency and specific gravity. The majority contain material of a chylous nature.

Symptomatology and Diagnosis.—There are no pathognomonic symptoms nor signs which make for the diagnosis of mesenteric cysts. So infrequently is this diagnosis made pre-operatively that Atchley[7] writes, in 1929: "The diagnosis of mesenteric cysts has, in a very few cases, if ever, been cor-

rectly made pre-operatively." This same statement was made by H. C. Deaver in 1909, and by C. P. G. Wakeley[8] in his report of a case of mesenteric cyst in an eight-day-old infant in 1932.

The symptoms are due for the most part to the size of the tumor and its encroachment upon the lumen of the intestine. If the growth is a rapid one the symptoms are acute. Hence acute intestinal obstruction with all its symptoms and signs develop. If a slow growth, then there are likewise the symptoms and signs of a chronic partial intestinal obstruction. The latter is especially true when middle-aged adults are the patients.

Of symptoms, *pain* in all its degrees seems to be the most common. This may be very acute or occur as a dull aching sensation lasting over a long period of time. It may be associated with nausea, and later vomiting, depending upon the pressure on the abdominal viscera, blood-vessels and nerves. Again, gaseous eructations are frequently encountered. Constipation, either alone or with alternating periods of diarrhœa, is often complained of by the patient; relief, if a slow-growing cyst, may be brought about by changes in posture. Moynihan emphasizes a rapid and serious wasting as a preva'ent sign of this condition but the majority of writers have failed to confirm this.

Physical examination offers the most aid. The presence of an abdominal tumor, usually in the lower quadrants, should bring the possibility of a mesenteric cyst to the examiner's mind. Moynihan and Shands speak of lateral mobility as a striking feature. This, of course, will depend upon the size of the cyst and whether or not it has become adherent to surrounding structures. Tympany has been found over the tumor in close proximity to dull areas. This is due to the empty intestine above the cyst.

Small cysts, of course, give no suggestive signs but may give rise to all the signs and symptoms of an "acute" abdomen.

The presence of the following symptoms or signs in one degree or another should bring to the physician's mind the possibility of a mesenteric cyst.

(1) Palpable tumor in the lower abdomen which is only moderately painful. (2) Constipation either alone or with alternating periods of diarrhœa. (3) Various degrees of indigestion, from mild gaseous eructations to severe nausea and vomiting with all the signs of acute intestinal obstruction. (4) A normal blood-picture unless dehydration and serious vomiting are present. (5) X-ray of the gastro-intestinal tract showing abnormal position of the intestine or some encroachment upon the lumen of the bowel. (6) Tympanitic areas in close proximity to dull areas.

The conditions which often simulate mesenteric cysts and must be differentiated are: (1) Intussusception. (2) Ectopic pregnancy. (3) Ovarian cysts. (4) Volvulus. (5) Malignant cysts. (6) Tuberculous cysts, especially in children. (7) Retroperitoneal growths. (8) Hydronephrosis. (9) Movable kidney. (10) Pancreatic cysts. (11) Cysts of the urachus. (12) Lipoma of the mesentery. (13) Pregnancy. (14) Internal hernia, in babies. (15) Acute abdominal conditions when cysts are small.

Complications.—(1) In over 50 per cent. of cases intestinal obstruction has complicated mesenteric cysts. (2) Intussusception from hyperperistalsis. (3) Peritonitis. (4) Hæmorrhage into the cyst. (5) Torsion of cyst with volvulus. (6) Rupture of cyst either into bowel or into peritoneal space. (Timbal.[9]) (7) Dilatation of stomach. (Atchley.) (8) Impaction in pelvis.

Prognosis and Treatment.—The reported cases give a mortality of about 35 per cent. Uncomplicated cases should recover following operations. In the event that resection of the bowel is necessary, the risk of course increases.

The *treatment* is primarily surgical. The most promising of all procedures is enucleation. Swartley,[10] in 1927, reported this having been done in ten of sixteen cases without a death. To this we add one more. Drainage alone is frequently all that is possible, especially in patients unable to stand a longer or more tedious operative procedure or when the cyst has become bound down by multiple adhesions. This procedure is apt to leave a draining sinus and enucleation must be done eventually. Coley[11] estimates the mortality of all classes of cysts drained to be about 6 per cent.

Resection of the bowel has the highest mortality of all the surgical procedures attempted. Miller reports three deaths in five cases, or 60 per cent. mortality. In these cases the high mortality was no doubt due to the critical condition of the patient.

Marsupialization has been performed successfully in a few cases. Along with aspiration it is now obsolete.

Conclusions.—(1) Mesenteric cysts are still of such rarity that they should be reported. (2) The case presented is of the rarer urogenital variety and adds another bit of evidence that such cysts are embryonic in origin. (3) Although the diagnosis is still difficult, the condition should always be considered in the diagnosis of the surgical abdomen. (4) The treatment of choice is enucleation.

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THE EFFECT OF BLOOD IN EXPERIMENTAL PERITONITIS

Dr. Lee Rademaker (by invitation) read a paper with the above title for which see page 414.

Dr. George P. Muller said that this study represents an enormous amount of work, and shows the importance of rigid control. Last Fall, Doctor Rademaker finished a series of experiments in which he brought out an idea regarding the causation of intra-abdominal adhesions and showed very definitely that infection of the abdominal wall would produce them. In their clinical records, they found seven operated on for adhesions and six of the seven had infected abdominal walls. This contribution of Doctor Rademaker's rather negatives the impression which most have that blood in the abdominal cavity is productive of adhesions or that this blood might favor infection in the peritoneal cavity. Apparently, he has shown in his study that blood does not favor infection, but, on the contrary, tends to minimize it. This may explain why the mortality of operation for ectopic pregnancy is so low. If the hæmorrhage is controlled, these patients get well and rarely come back complaining of severe abdominal adhesions.

RECURRING EXTERNAL DISLOCATIONS OF THE PATELLA

Dr. B. Franklin Buzby read a paper with the above title for which see page 387.

BILATERAL AVULSION OF THE LESSER TROCHANTER OF THE FEMUR

Dr. DeForest P. Willard and Dr. Jesse T. Nicholson (by invitation) presented a colored boy, aged twelve years, who gave a history, beginning December 13, 1930, of pain in his *right* thigh in the region of Scarpa's triangle without previous injury or accident. He was not handicapped in walking. December 18, 1930, he slipped on some ice and fell with the leg extended, landing on the right side. He was forced to walk with a limp after this. That night the pain became severe and the leg stiff. The following day he was carried into the accident ward. A posterior dislocation of the hip was diagnosed by the interne. The leg was manipulated and a "snap" suggestive of reduction obtained. Function immediately appeared normal. The röntgenological check-up, however, revealed a separation of the epiphysis of the lesser trochanter. He was placed in bed with sandbags along the side of the leg, and a few days later a plaster spica was applied to hold the right thigh in partial flexion, slight internal rotation and mild adduction. He was discharged on crutches the following day (December 24, 1930). He failed to return to the clinic until April 6, 1931, at which time the plaster bandage was removed. Hip motion was free and painless. July 31, 1931, both hips were equal in range of motion.

October 10, 1931, he fell, catching himself on his *left* knee with immediate pain in left groin. This persisted and was accentuated by motion. Two days later (October 12) he walked into the clinic favoring the left leg. The thigh was held in 15° flexion, 5° adduction, but not rotated. Passive motion was possible from 170° to 90°, abduction 5°, adduction 20°, internal rotation 65°, and external rotation 0°. There was tenderness on deep pressure in Scarpa's triangle. The right hip was normal. Separation of the lesser trochanter of the left femur was verified by X-ray. A short plaster spica, holding the thigh in 90° flexion, 5° adduction and 5° internal rotation was applied. After six weeks this bandage was removed and the leg brought down to 165° and another bandage applied for two weeks. January, 1932, there was full return of power and motion.

The reporter added that while the literature revealed many cases of avulsion of the lesser trochanter of the femur, there was no record of a bilateral involvement. The earliest case was accredited to Morgagni, Moreau, and Lecouturier. Previous to the advent of röntgenology (1908) but ten cases were diagnosed.

MULTIPLE TRAUMATIC BURSITIS

Dr. DeForest P. Willard, and, by invitation, Dr. Jesse T. Nicholson presented a colored man, fifty years of age, who had sustained an injury to his left knee. He bled profusely. Upon examination he was found to have a tumor growth (sixteen centimetres in length, ten centimetres in thickness and 8.5 centimetres in width) on the anterior surface of the left knee (Fig. 5.) The overlying skin was scaly, indurated and adherent. The mass was hard and firm with small flocculent areas. At its lower border were three ulcerated areas; the largest, two centimetres in diameter, was bleeding pro-

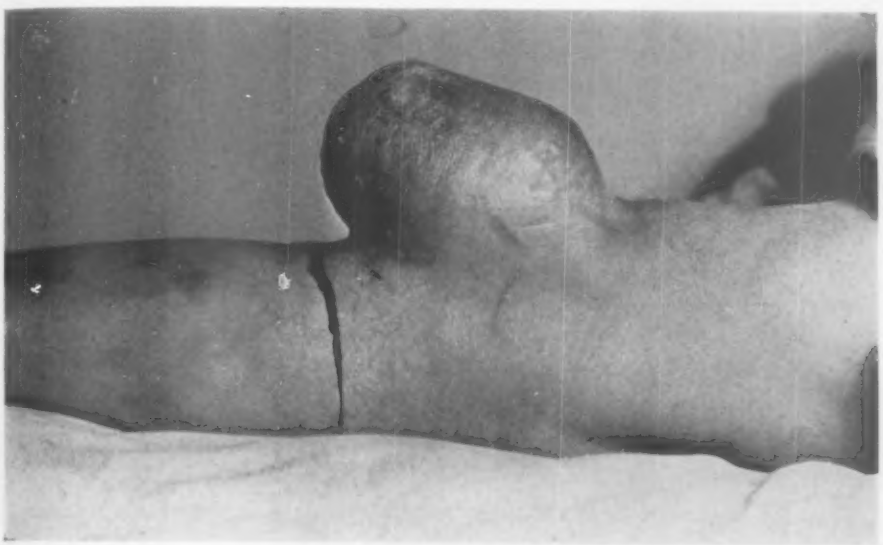


Fig. 5.—Large pre-patellar bursa of the left knee.

fusely, but could be controlled by pressure. Joint motion was not restricted. There was no pain nor tenderness. Further examination disclosed similar but smaller tumors which were uniformly firm; one just below the patella of the right knee and the other distal to olecranon of the left below. (Figs. 6 and 7.) The overlying skin was not ulcerated. The inguinal glands were readily palpable but not unduly enlarged. The epitrochlear nodes bilaterally were enlarged. Further physical findings were essentially negative.

Twelve years previously small lumps were noticed almost simultaneously on both knees and left elbow. These gradually increased in size, never giving any pain. Three years ago the patient had a fall on left knee. Since then it had become more swollen. At times his trousers rubbed the skin and it became abraded. For past two days it had bled enough to keep a bandage on it. The present hæmorrhage occurred while walking.

He gave a history of a Neisserian infection in 1898; typhoid fever, influenza and rheumatic fever involving right knee; alcohol in moderation. He worked as a laborer, and at intervals for seventeen years had to support himself on his knees and left elbow for four hours at a time while filling a coal bin. The Wassermann blood reaction was anti-complementary, and the Kahn test weakly positive. Röntgenologically the tumor

mass showed no invasion of bone, but small, calcified areas. Previous to operation if dressing was removed from left knee, bleeding was profuse. The differential diagnosis stood between gumma, traumatic bursitis and neoplasm.

FIG. 6.—Comparative size of bursa right knee.

January 20, 1931, under general anæsthesia, the growths were removed; they were found to be well encapsulated but very adherent to the neighboring structures due to

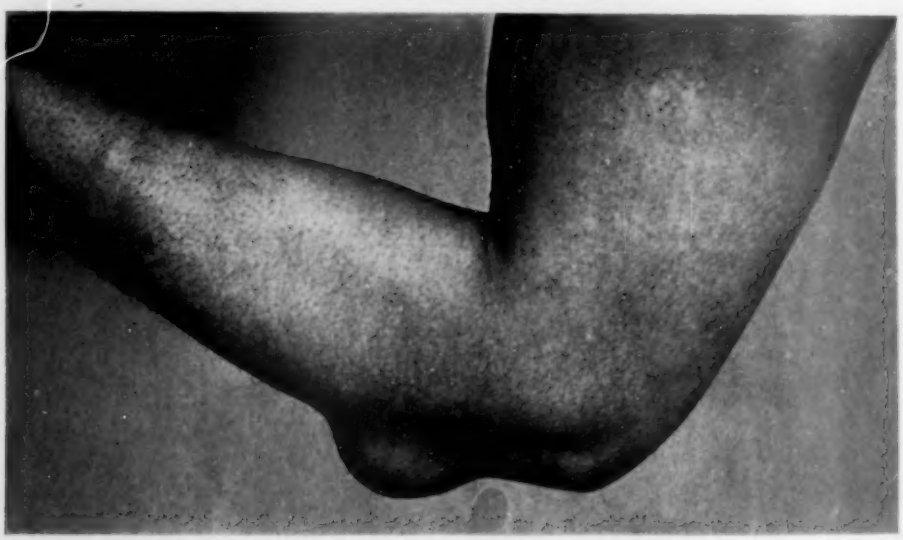


FIG. 7.—Subolecranon bursa.

dense scar tissue. The wounds were closed without drainage and healed by first intention.

Three months after operation no recurrence had taken place.

KLIPPEL-FEIL SYNDROME

Dr. De Forest Willard, and, by invitation, Dr. Jesse T. Nicholson read a paper with the above title.

Dr. DeForest P. Willard said that the fusion between the first cervical vertebra and the occipital bone is apparently not quite so rare as one would be led to believe from the literature. In teaching osteotomy for a good many years, he could recall several cases of adults in which the occipital bone was intimately fused with the occipital vertebra. We find not infrequently osseous fusion between the first cervical vertebra and the articular surfaces of the occiput. These cases are very often wrongly diagnosed as tuberculosis of the cervical vertebra. That is one of the reasons they come from the dispensary diagnosed as old or beginning Potts' disease and from the appearance of the neck it is rather hard to make a differential diagnosis. Unless the history is very clear it can be mistaken for Potts' disease due to the low-grade inflammation.

Dr. Jesse T. Nicholson said that regarding the differential diagnosis from cervical Potts' disease, the principal features are the absence of muscular rigidity, the freedom from pain with motion and the bone architecture as shown by the Röntgen film.

MEMOIRS

ASTLEY PASTON COOPER ASHHURST, M.D.

1876–1932

ASTLEY PASTON COOPER, the son of the scholarly John Ashhurst, Jr., was born in Philadelphia in the Centennial Year, 1876. He received all of his early school education and medical training in that city. The Bachelor of Arts degree in 1896 and the degree of Doctor of Medicine in 1900 were con-

ASTLEY PASTON COOPER ASHHURST, M.D.

ferred by the University of Pennsylvania. After his graduation from the Medical School, from 1900 until 1904, he was an interne, first at the Children's Hospital and later at the Episcopal Hospital.

From 1904 until 1914 he served an apprenticeship in various dispensaries. In 1913 he was elected Surgeon to the Orthopedic Department and Associate Surgeon to the Surgical Service of the Episcopal Hospital. In 1914 he was appointed Surgeon to the Orthopedic Hospital and in 1915 he was promoted

to Surgeon at the Episcopal Hospital. For nine years, 1911 to 1920, he was an Instructor in Surgery at the University of Pennsylvania and for several years prior to his resignation in May, 1932, he had been Professor of Clinical Surgery at his Alma Mater. He was an authority on medical history.

He loved to teach and the students respected his knowledge and his mastery of fundamentals, and, in spite of a slight hesitancy in speech, his lectures and quizzes were always popular.

As a surgeon he was methodical in the superlative degree, even such details as choosing the instruments, or handling of the instruments, or applying the bandage, all of them were his job and a surgeon's duty. His carefulness did not make him a putterer with a scalpel and needle; his knowledge of anatomy made that impossible. Nor was his care exhibited only in the operating room: he made his own examination, his own diagnosis, looked at the X-ray plates, consulted with his medical confreres, and saw with his own eyes the pathological sections.

As an author he possessed few equals. His purely scientific articles were clear and simple, and his essays were examples of rhetoric that reflected his scholarly attainments. His magazine articles fill four large volumes, and, between the years 1902 and 1920, he was the author of eighty-two magazine articles, co-author in ten others, wrote numerous book reviews, edited two volumes of the Episcopal Hospital Report, was a co-author of two text-books, the author of a monograph, and wrote his own work, "Surgery: Principles and Practice."

Astley Ashhurst found time to serve his country. He believed in preparedness and put his stamp of approval on the idea by attending the Officers Training Camp at Plattsburg in 1916. After America's entry made the last war a world war, he organized Base Hospital 34 at the Episcopal Hospital and was its first Director. He went to France with the unit on December 15, 1917, and returned to America in January, 1919. In France he served at the front with the French and the Americans, and after the Armistice was appointed as a consultant to the hospital centre at Savenay. On his return home and until his discharge from the army on April 16, 1919, he acted as Chief of the Surgical Service at the Walter Reed Hospital. He entered the army as a first lieutenant and at the time of his discharge he had been promoted to colonel. For his army service he received a citation for "exceptionally meritorious and conspicuous service with Base Hospital 34."

In 1929 it was noticed that he was having dizzy spells. In the latter part of May, 1930, while driving on the Roosevelt Boulevard he had his first attack of cerebral thrombosis and crashed into a tree. He got out of his car, took a picture of the crash and then made his way to his office by trolley and bus. On his arrival home several hours later it was noticed that he had a left hemiplegia. After months of rest he entirely recovered the use of his hand and leg and returned to operating and teaching. However, in the latter part of August, 1932, he had a second attack of thrombosis from which he rallied, but a third attack caused his death September 19, 1932.

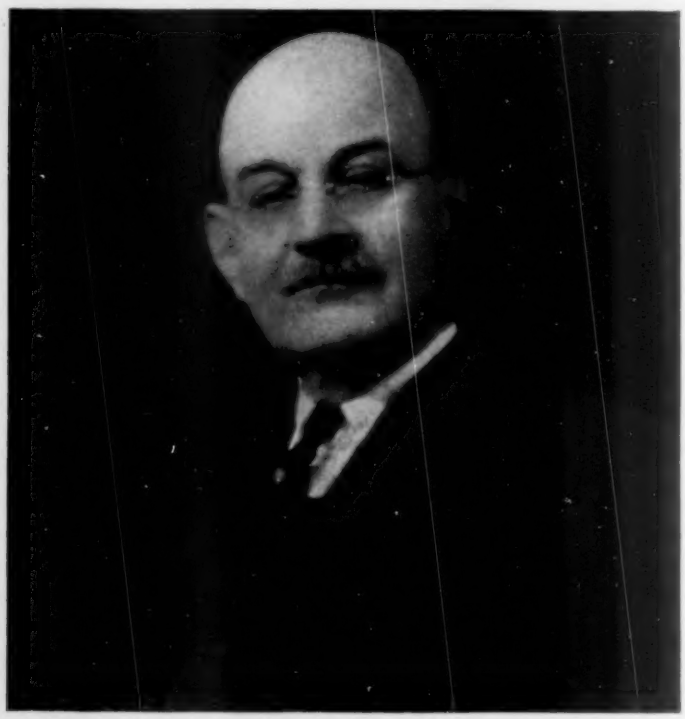
EDWARD T. CROSSAN

DAVID BARROW, M.D.

1858-1932

DR. DAVID BARROW, Kentucky's most distinguished surgeon, died at his home in Hampton Court on Thursday, August 18, 1932, after an illness of six months.

Doctor Barrow was born at "Afton Villa," the Barrow ancestral home near St. Francisville, Parish of West Feliciana, Louisiana. Born August 31, 1858, son of David Barrow, of St. Francisville, Louisiana, and Susan



DAVID BARROW, M.D.

Mitchum Woolfolk, "Oak Hill," near Versailles, Woodford County, Kentucky. Doctor Barrow received his early education at Kentucky University, Lexington, Kentucky, and the University of Louisiana at Baton Rouge; his medical education at Tulane University; and post-graduate work at Bellevue Hospital, New York City.

Doctor Barrow received his M.D. degree from Tulane on March 19, 1880, and practised in New Orleans before coming to Lexington in May, 1887. For many years Doctor Barrow, like all physicians of that date, did

a general practice but was looking forward to confining his work to surgery. This he did. During his long professional career, he received many deserved honors. He was a member of a large number of organizations and had the distinction of being the only surgeon in Kentucky who was a Senior Fellow of the American Surgical Association and the Southern Surgical Association. His World War record is notable, having organized the Good Samaritan Hospital Unit, known as Base Hospital No. 40; commissioned as Major August 11, 1917; sent to Camp Zachary Taylor; then overseas to Southampton, August, 1918; was sent to France, then back to London and was commissioned Lieutenant-Colonel August 28, 1918. He was commanding officer of Base Hospital No. 40 until his return to the United States March 6, 1919.

Doctor Barrow organized the Lexington Clinic in 1917. Its decided success was largely due to his operative skill, his discriminative diagnostic ability, his rare judgment, and his personal charm.

Doctor Barrow made many contributions to medical and surgical literature. These were published in the journals of that date, and the transactions of the State Medical Association.

The death of his wife—Mary Blunt Parham, the sister of Dr. Frederick W. Parham, of New Orleans—in November, 1908, the tragic death of his youngest son, David, in July, 1914, and that of his oldest son Dr. Woolfolk Barrow in July, 1923, would have crushed the spirit of most men, but his indomitable will and consummate courage sustained him in this supreme trial; his brave soul carried on to the end.

The Lexington Herald, of August 19, 1932, contained these words of eulogy:

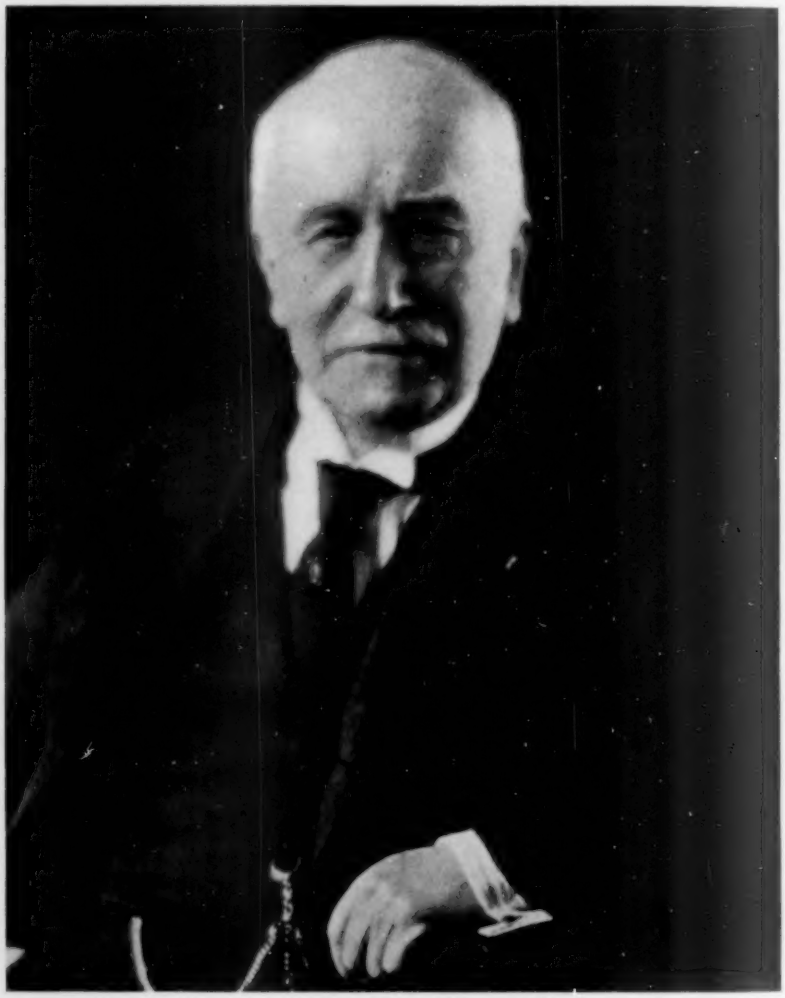
> A great surgeon, a beloved physician, a noble gentleman, a revered citizen was David Barrow. In every sphere in which he played a part, through every contact his influence was noble. It is difficult even to indicate, impossible adequately to estimate the influence Doctor Barrow exerted through the long years he gave to profession and to friends. Gentle, with the never failing gentleness of high courage and sweet tolerance; generous beyond limit of acceptance by others; faithful to obligation, great or small, his life was a benediction.
>
> J. W. Pryor.

WILLIAM WILLIAMS KEEN

1837-1932

It is difficult to write a comprehensive memoir of Doctor Keen because of the abundance of material from which to draw.

Doctor Keen's accomplishments in the field of medicine and in civic and



William Williams Keen, M.D.

educational affairs were remarkable and could have been obtained only by one possessed of his earnestness, enthusiasm and love of work, none of which had abated when he had passed into his ninth decade. During the forty years that the writer was more or less intimately associated with him, he was impressed constantly with his enthusiasm, his optimism, his deep religious convictions and his tireless energy. His multifarious duties and engagements

throughout his career were met with the most exact promptness and given the most careful consideration. He often said that it was the busy man who was always prompt and who never forgot an engagement. Even in the busiest period of his very busy life he was rarely late for a lecture, an operation or a consultation.

William Williams Keen was born in Philadelphia January 19, 1837, was graduated from Brown University in 1859 and from the Jefferson Medical College in 1862. He at once entered the Army as acting Assistant Surgeon and soon became generally known because of his association with Mitchell and Morehouse in their notable work and publications on nerve injuries. After the War, he spent two years in Europe.

In 1866, he returned to Philadelphia, began the practice of medicine and soon acquired teaching positions. For nine years he lectured on pathological anatomy at the Jefferson Medical College. During the same period he conducted the Philadelphia School of Anatomy in which he had been preceded by so many distinguished surgeons. From 1876 to 1889 he was Professor of Artistic Anatomy at the Philadelphia Academy of Fine Arts and from 1884 to 1889 Professor of Surgery at the Women's Medical College. During the period between 1866 and 1889 Doctor Keen became known in the world of surgery largely through his contributions to literature. Up to the end of this period, he had no large hospital service, but was on the surgical staff of St. Mary's and St. Agnes' Hospitals and developed a large surgical practice.

In the year 1889, on the death of the younger Gross, he was elected one of the Professors of Surgery at the Jefferson College, the other being John H. Brinton. This election marks a distinct epoch in the surgical career of Doctor Keen. He gave up his other hospital and college positions and devoted himself assiduously to teaching, to his surgical service in the Jefferson Hospital, and to writing. His fame and reputation spread rapidly and he soon became a conspicuous figure in the world of medicine. Keen's lectures were all carefully prepared and he always had before him synopses which were carefully followed, rendering note-taking easy on the part of the student. Doctor Keen kept accurate notes of all his hospital patients in his own office which enabled him easily to report his experiences with accuracy. His well-ordered life made possible the accomplishment of work which would easily have staggered any two men whose lives were not so well organized. It was, I am sure, this characteristic of order and arrangement which enabled him to write so extensively and to read not only everything that was worth reading in surgical literature, but a mass of other papers and books relating to science, political economy and religion.

As an operator he was bold but very painstaking and careful. He rarely showed hesitation and never a lack of self-confidence. But for these qualities he could never have contributed so much to the advancement of surgery, particularly that of the brain. He was America's first "brain surgeon" and soon gained and held preëminence in this field of surgery. It is impossible in a brief sketch such as this to discuss or even enumerate Doctor Keen's con-

tributions to literature, but the following, prepared by himself, will give some idea of the wide scope of his writing.

Reflex Paralysis and Gun Shot Wounds and Other Injuries of Nerves (both with Weir Mitchell and Morehouse), 1864; Keen's Clinical Charts, 1870; History of the Philadelphia School of Anatomy, 1874; Early History of Practical Anatomy, 1870; History of the First Baptist Church of Philadelphia, 1898; Surgical Complications and Sequels of Typhoid Fever, 1898; Addresses and Other Papers, 1905; Animal Experimentation and Medical Progress, 1914; The Early Years of Brown University, 1764–1770, 1914; Ether Day Address, 1916; Treatment of War Wounds, 1917; Surgical Operations on President Cleveland, 1917; Clover Lectures at Brown University on Medical Research and Human Welfare, 1917; Selected Papers and Addresses, 1922, Editor; Heath's Practical Anatomy, 1870; Diagrams of the Nerves of the Human Body, by W. H. Fowler, 1872; American Health Primers, 1879–1880; Holden's Medical and Surgical Landmarks, 1881; Gray's Anatomy, 1887; American Text-Book of Surgery with J. William White, 1892, 1903; I Believe in God and Evolution, 1922; Everlasting Life, 1924; Keen's System of Surgery, eight vols., 1906–1921.

Doctor Keen was an enthusiastic patriot and it was with pride that in his later life he referred to his military service in three wars.

Honors were literally heaped upon him; he was elected president of practically every society of which he was a member, among them the College of Physicians of Philadelphia, the American Medical Association, the American Surgical Association, the International Society of Surgery and the American Philosophical Society; he was an honorary mmber of most of the European surgical societies and held honorary degrees conferred by the following institutions: Brown, Northwestern, Toronto, Edinburgh, Yale, St. Andrews, Pennsylvania, Upsala and Harvard. There have been few American surgeons so universally respected and honored.

Aside from his professional work Doctor Keen gave a great deal of his time to matters of education, civic improvement and to his church. His only recreations were reading and travel. A continental trip was usually made in the summer, and in his late life his travels were completed with a trip around the world. At the time of his death on June 7, 1932, he was the oldest Fellow of this Association both in years and duration of membership, having been one of the original Fellows. His interest in the Association was very deep and his attendance at the meetings was regular even after his retirement. The year of his Presidency was in 1898.

The death of this great surgeon June 7, 1932, in his ninety-sixth year, not only saddened the hearts of the older Fellows of the Association, but also of those much younger who had drawn an inspiration from his enthusiasm, his energy and his accomplishments.

J. H. Gibbon.

EDITORIAL ADDRESS

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